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We are also anxious to report the Proceedings of Colleges, Universities, Societies and Associations in every part of the world in so far as they contribute to the advance of orthopaedic surgery. A measure of international co-operation in publication has already been achieved and this will be fostered and, we hope, increased.

Manuscripts offered for publication in the British volume should be addressed to the Editor, Journal of Bone and Joint Surgery, Ludgate House, Fleet Street, London. The Editorial Secretary of the Board is at the service of authors, and will assist in any way she can. Manuscripts offered for publication in the American volume should be addressed to the Editor, Journal of Bone and Joint Surgery, 8 The Fenway, Boston 15, Massachusetts.

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The names of Journals should be given in full; it is not proposed to adopt the "World List" of abbreviations. Every bibliography and list of references will be checked by the Editor, but much delay will be avoided if authors would be good enough to pay careful attention to accuracy.

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The Journal of Bone and Joint Surgery

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The Journal of Bone and Joint Surgery

EDITORIALS

NEONATAL SCIATIC PALSY

In this number of the Journal an important contribution is made by Fahrni of Vancouver who reports eleven infants born with sciatic palsy. He suggests that the nerve lesions might have arisen from the pressure of a foetal hand on the sciatic nerve trunk. His paper was received for publication nearly two years ago, and when it was discussed by members of the British Editorial Board, as every paper is discussed in great detail, his conclusions were hotly contested. It may be said that the paper should nevertheless have been published forthwith, and that possible errors of conclusion could still have been corrected by later correspondence; but, rightly or wrongly, the Editorial Board did not take this view. Publication was delayed until experimental studies had been completed in the Departments of Physiology and Pharmacology of the University of Liverpool, together with further investigations at the Liverpool hospital where Fahrni was working at the time of his report. We now record the results of these studies by O'Malley, McCandless and Hudson, reported by McFarland as an addendum to Fahrni's paper. They suggest that no matter how remote the umbilical cord may seem to be from the sciatic nerve, the real cause of neonatal sciatic palsy is the injection of noxious drugs into the umbilical artery.

Meanwhile a paper by Mills of Birmingham, in which reference is made to Fahrni's cases at the Walton Hospital, has been published in the British Medical Journal (August 27, 1949). Mills described eight cases of neonatal sciatic palsy seen in the Birmingham Maternity Hospital. He attributed the paralysis to the injection of " nikethamide " into the umbilical cord and concluded that although the etiology of neonatal sciatic palsy was not yet proved, it seemed probable that " the lesions may be due to the injection of drugs into an artery in the umbilical cord," thus supporting the conclusions of Liverpool workers whose studies were inspired by the shrewd observations of Mr Fahrni.

ON WRITING

In the last British number of the Journal, in an editorial article, we quoted the words of Alvarez of the Mayo Clinic: " There probably never was a good paper which was not worked over several or many times." From the communications received, it is clear that many young contributors still believe that the art of writing is inborn in some and denied to others, and that whereas they themselves cannot write, some of their colleagues are able to sit down and compose fluent English without effort. How wrong they are! It was Dostoievsky who said: " And as for me this is my story: I worked and was tortured. You know what it means to compose? No, thank God, you do not."

Nearly all good writing is torture to the writer. He must discipline himself to long-continued effort—writing, rewriting and rewriting yet again—always seeking to improve the turn of phrase and the choice of word, and with each successive transcript deleting much that was written before. Tolstoy said: " I cannot understand how anyone can write without rewriting everything over and over again." Flaubert was no less honest in his admission: " I am going on very slowly. I give myself an accursed lot of trouble. I have just suppressed

phrases which have cost me the entire work of many days." It might even be said with W. B. Yeats that " the correction of prose, because it has no fixed laws, is endless "; but we do not ask quite so much of our contributors—and indeed, if we did, we should have nothing to publish. With sufficient effort, prose, like poetry, " comes right with a click like a closing box."

Another observation by Flaubert gives solace to an editor whose uneasy writing is often composed in the midnight hours: " I have just spent a week, alone like a hermit, and as calm as a god. I abandoned myself to a frenzy of literature. I got up at mid-day; I went to bed at four in the morning; I smoked fifteen pipes a day; I have written *eight pages*." How satisfying it is to know that one is not alone in keeping curious hours, smoking too much, and writing too little!

There is of course danger in sitting faced with a blank sheet of paper desperately trying to get started " with your head in your hands trying to squeeze your unfortunate brain so as to find a word." I have vivid recollections of the days I wasted composing the first paragraph of the first chapter of a book I proposed to write. It was not until I began in the middle of the chapter that the words began to flow. The first draft of writing should pay no regard to the final form; it should be an inspired outpouring of ideas and observation; the work of creation must go on briskly. At this early stage we must write—at all costs we must write—we must at least write something. Only then should the polishing begin; but thereafter it should go on, and it should go on repeatedly.

In the words of de Maupassant: " Whatever one wishes to say there is one noun only by which to express it, one verb only to give it life, one adjective only which will describe it. One must search until one has discovered them, this noun, this verb, this adjective. We need fewer nouns, verbs and adjectives with almost imperceptible differences of meaning; instead, we need more different phrases, phrases of varying construction, skilfully terse, compact of sonorousness and learned rhythms." He went on to say that it was hard " to mould the phrase to one's own will, to make it say everything, even that which is not expressed." It is indeed hard—and still harder to make it " skilfully terse "; but what joy and satisfaction there is in the achievement.

UNIVERSITY DEGREES AND COLLEGE DIPLOMAS

Is there any special merit in the degree of Master of Orthopaedic Surgery? Should a surgeon who is a Fellow in one of the Royal Colleges of Surgeons aspire also to be Master of Surgery in one of the Universities; or are the College diplomas exactly equal and comparable to the University degrees? Is it possible that the membership or licentiateship of a College of Physicians or Surgeons should be the qualifying examination to practise, and that even the Bachelors' degrees of medicine and surgery should be reserved as a special mark of academic distinction? These questions are discussed in this number of the Journal in relation to the report from the University of Liverpool on the results of recent examinations for the degree of Master of Orthopaedic Surgery. EDITOR.

THE ENDOCRINE BASIS FOR SLIPPING OF THE UPPER FEMORAL EPIPHYSIS

An Experimental Study

W. ROBERT HARRIS, TORONTO

From the Department of Anatomy, University of Toronto *

An endocrine basis for slipping of the upper femoral epiphysis is suggested by the fact that the lesion is nearly always accompanied by abnormalities of growth which in themselves appear to be caused by an endocrine disorder. This is especially true of those patients from whom an inadequate history of injury can be obtained. The usual disturbance of growth is the adiposo-genital syndrome, a condition characterised by obesity and deficient gonadal development; less commonly there is a history of very rapid growth, resulting in a tall, thin child (Key 1926). In the obese children there appears to be a low level of sex-hormone in the circulation; while in the tall, thin children there seems to be an excessively high level of growth-hormone. Both growth-hormone and sex-hormone alter the rate of proliferation of the cartilage cells in the epiphysial plates, with consequent changes in the thickness of the plates and in the rate of skeletal growth. Anterior pituitary growth-hormone stimulates the proliferation of these cells directly, with increase in the thickness of the plates and in the rate of skeletal growth (Ray *et al.* 1941). The sex-hormones slow the proliferation of these cells with decrease in the thickness of the plates and in the rate of skeletal growth (Gardner *et al.* 1943). Oestrogen produces this effect by inhibiting the secretion of growth-hormone by the anterior pituitary, rather than by direct action on the epiphysial plate (Zondek 1936). It is probable that testosterone acts in the same manner, although the evidence on this point is not as clear as in the case of oestrogen (Rubinstein *et al.* 1939).

From these observations it appears that between the time of activation of the gonads and the time that growth ceases, the structure of the epiphysial plates could be dependent on the relative levels of growth-hormone and sex-hormone in the circulation. Since it is during this interval that slipping of the upper femoral epiphysis occurs, with its associated abnormalities of growth, and since these growth disturbances are characterised by evident alterations in the level of growth-hormone and sex-hormone, it is not unreasonable to assume that an imbalance between these two endocrines is the cause of structural weakness in the epiphysial plates which makes them more susceptible to shearing stress. To test this hypothesis, an apparatus was used to measure the shearing strength of the epiphysial plates of rats. This paper reports observations made with this apparatus on animals receiving growth-hormone, animals receiving oestrogen and untreated control animals.

MATERIALS AND METHODS

Young albino rats of the Wistar strain, weighing approximately 150 grams, were used throughout the experiment. These were separated into three groups, each comprising five male and five female animals. The animals of one group were untreated and used as controls; those of a second group were gonadectomised and given 1 milligram of anterior pituitary growth-hormone, intraperitoneally, daily†; those of the third group were given 200 gamma

* Supported by a grant from the Banting Research Foundation.

† The growth hormone was prepared according to the procedure described by White (1944). The animals were gonadectomised in order to eliminate the effect of possible contamination of the growth hormone preparation with gonadotrophic hormone.

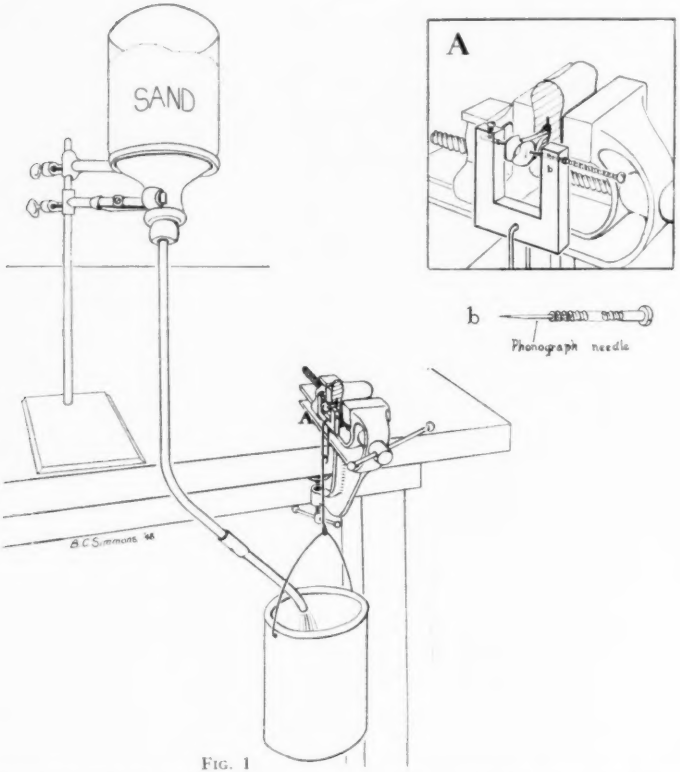


FIG. 1

Apparatus used for determining the shearing strength of epiphysial plates. The clamp was cut from quarter-inch aluminium plate. Each arm was fitted with a phonograph needle (one of them adjustable) which grasped the epiphysis securely. Crushing of the shaft of the bone was prevented by inserting it through a one-holed rubber stopper which was in turn clamped between the jaws of the vice.

of oestradiol benzoate in oil, intramuscularly, three times weekly. The animals were fed on a diet of Purina Fox Chow to which sufficient amounts of vitamins A and D were added; they were maintained in separate cages according to their group and sex.

After twenty-eight days, the animals were killed by chloroform and both tibiae were dissected out. One tibia was freed of muscle and soft tissue, and fastened by its shaft in the apparatus illustrated in Fig. 1, with its anterior border facing downwards (to eliminate the interfering effect of the projection of the tibial tuberosity on the shearing strength of the plate) and with its proximal epiphysis projecting from the vice. The clamp (Fig. 1, inset), with the empty bucket suspended from it, was fastened to the proximal epiphysis, and sand was poured into the bucket until the epiphysis separated. The weight of the bucket and its contents was recorded and used as a measure of the shearing force required to detach the epiphysis. The other tibia was fixed and decalcified in Bouin's fluid and sectioned longitudinally by the paraffin method.

In addition to this material, tibiae from several normal rats, also weighing about 150 grams, were obtained. Some were sectioned without decalcification and stained for calcium distribution by the von Kossa method. Others were stripped of soft tissue, and

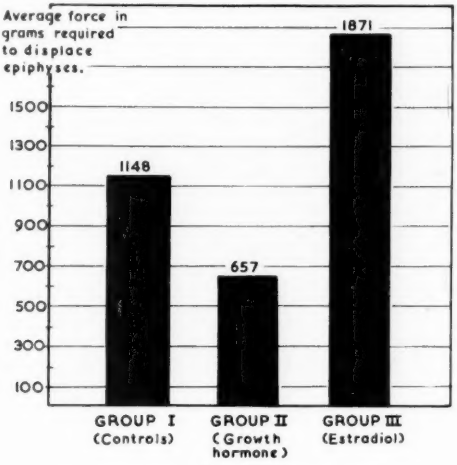


FIG. 2

Graph showing the average force required to detach the epiphysis, the figures being based on the results from all male and female animals in each group. (See Table I.)

TABLE I

	Controls	Growth-hormone	Oestrogen
MALES . .	1,380	570	1,931+
	1,260	540	1,846
	960	960	1,931+
	1,620	420	1,931+
	780	720	1,931+
Average . .	1,200	642	1,914
FEMALES . .	1,363	900	1,931+
	1,193	600	1,590
	738	720	1,931+
	1,108	780	1,931+
	1,080	360	1,761
Average . .	1,096	672	1,828

Force in grams required to detach epiphyses.
(When fully loaded with sand, the bucket weighed 1,931 grams.)

the proximal epiphysis was partly detached from the shaft, after which the specimens were stained for phosphate distribution by the Gömöri technique (Gömöri 1933).

RESULTS

The force required to detach the epiphyses in each group of animals is summarised by the graph in Figure 2, and shown in detail in Table I.

Histological changes—1) *Growth-hormone treated animals*—On superficial examination, the epiphysial plates of the animals in this group appeared to be normal. However, on comparing them with the controls they were found to be much thicker than in the normal rats (Figs. 4*a* and 4*b*). This thickening occurred chiefly in the layers of proliferating and maturing cartilage cells in the plate. In addition, numerous mitotic figures were found amongst the cells on the epiphysial side of the plate (Fig. 5). These were seldom found in the epiphysial plates of normal animals.

2) *Oestrogen treated animals*—The epiphysial plates from these animals (Fig. 4*c*) were much thinner than those from the control group (Fig. 4*b*). The cells in the cartilaginous part of the plates were irregularly arranged and did not form orderly rows as in the normal animals. In addition, the trabeculae in the metaphysis were increased in number and thickness. This increased bone formation invaded the layer of hypertrophied cartilage cells on the diaphysial side of the plate (Fig. 6).

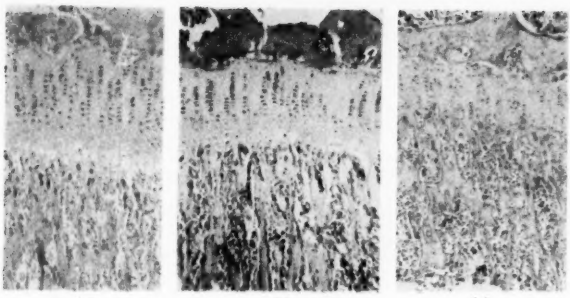
DISCUSSION

The structures in the normal epiphysial plate that are responsible for its strength can be identified in longitudinal sections. When seen in this manner, the plate may be divided into four layers (Fig. 7). 1) A layer of resting cartilage cells on the epiphysial side of the plate. These cells are arranged in irregular clusters, separated from one another by abundant cartilage intercellular substance which is in firm contact with the cortical bone of the epiphysis. 2) The next layer consists of proliferating cartilage cells arranged in orderly rows parallel to the long axis of the bone. Each row is separated from its fellows by intercellular substance containing bundles of collagenic fibrils (Fig. 3). These fibrils make a significant contribution to the strength of the plate in this region. 3) As new cartilage is added to the advancing edge of the plate by the division of cartilage in the second layer, those cartilage cells already present enlarge as they grow older, forming a layer of hypertrophied cartilage cells. The lacunae of these cells become so large that the intercellular substance remaining between them forms thin, delicate walls upon which the third layer is entirely dependent for its strength. 4) The diaphysial side of the layer of hypertrophied cartilage cells is strengthened, however, by the precipitation of mineral salts in its intercellular substance (Fig. 8). This forms the fourth layer of the plate, and is commonly termed the "zone of provisional calcification." In addition to these four layers, the region of trabecular formation in the metaphysis also contributes to the strength of the plate. Here osteoblasts lay down bone matrix about the spurs of calcified intercellular substance on the diaphysial side of the fourth layer, thus uniting the plate firmly to the shaft of the bone and materially increasing its strength.

FIG. 3

Proximal tibial epiphysial plate, untreated rat, toluidene blue stain, ×400. Note the compact rows of collagenic fibrils in the second layer.

It may be expected from this description that the weakest part of the plate is its third layer, where its strength is entirely dependent on thin, delicate walls of uncalcified intercellular substance. That this is true was first demonstrated by Haas (1917) who found that, when the periosteum about the periphery of an epiphysial plate was removed, the epiphysis could be detached from the shaft by gentle pressure. The line of separation was constant, always passing through the layer of hypertrophied cartilage cells. The demonstration of Haas is made more striking by staining the material for mineral distribution when it may be seen clearly that the plane of cleavage passes through the third layer (Fig. 9).



(*a*) (*b*) (*c*)

FIG. 4

Proximal tibial epiphysial plate from each group of animals (× 150): (*a*) growth-hormone treated; (*b*) untreated control; (*c*) oestrogen treated.

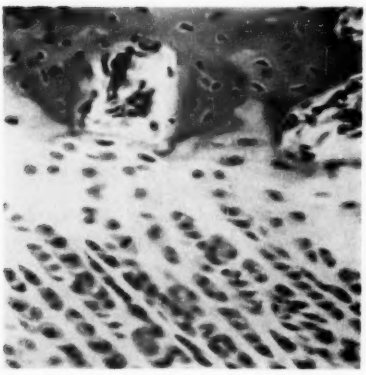


FIG. 5

FIG. 6

Figure 4 shows the proximal tibial epiphysial plate from growth-hormone treated animal (× 400). Note mitotic figures in second layer.

Figure 5 shows the proximal tibial epiphysial plate from oestrogen treated animal (× 350). Note decrease in thickness of the epiphysial plate, increased bone formation in the trabeculae, and the manner in which this has invaded the diaphysial side of the fourth layer of the plate.

FIG. 7

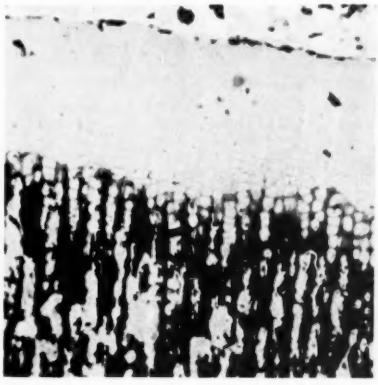


FIG. 8

Figure 7 shows the proximal tibial epiphysial plate, untreated control rat (× 300): (*a*) layer of resting cartilage cells; (*b*) layer of proliferating cartilage cells; (*c*) layer of hypertophied cartilage cells; (*d*) zone of provisional calcification; (*e*) trabeculae formation in the metaphysis.

Figure 8 shows the proximal tibial epiphysial plate, untreated rat, v. Kossa silver nitrate stain for calcium (× 200). Note that the zone of provisional calcification is confined to the diaphysial side of the layer of hypertrophied cells.

With establishment of the fact that the weakest part of the epiphysial plate is its third layer, the interpretation of the effects of growth-hormone and oestrogen on its shearing strength is facilitated, for the thickness of this layer is altered by each hormone. Growth-hormone increases the thickness of the third layer by increasing the rate of proliferation of the cartilage cells in the second layer, thus making more cartilage cells available for maturation. The consequent increase in thickness of the third layer makes the plates more susceptible to shearing stress and therefore less force is required to detach the epiphyses in the animals given growth-hormone.

By interfering with the secretion of growth-hormone from the anterior pituitary gland, oestrogen decreases the rate of proliferation of cartilage cells in the second layer of the plate. Fewer cartilage cells are therefore available for maturation, and the third layer decreases in thickness. In consequence, more force is required to detach the epiphyses in the animals given oestrogen. In addition to this indirect effect on the epiphysial plate, oestrogen apparently stimulates endochondral bone formation directly. In birds, this is related to the need for rapid mobilisation and storage of calcium during the ovulatory cycle (Bloom *et al.* 1940), but in mammals the nature of the phenomenon is not clearly established. In any case, it contributes further to the narrowing of the third layer and hence to the strength of the plate.

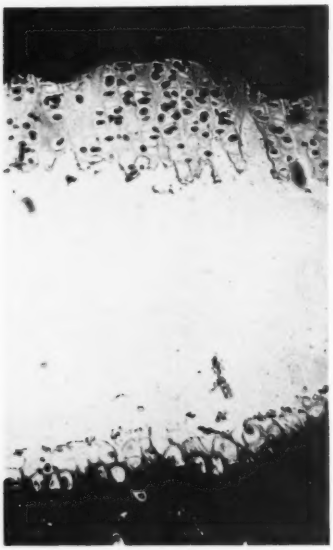


FIG. 9

Proximal tibial epiphysial plate, untreated rat, partly detached from the shaft and stained for phosphate distribution by the Gömöri method, ×150. Note that the plane of separation passes through the third layer, *i.e.*, the uncalcified part of the layer of hypertrophied cells.

The histological changes produced in the epiphysial plates by growth-hormone and oestrogen have been described by previous investigators. This paper relates these structural changes to alterations in the shearing strength of the epiphysial plate: growth-hormone decreases the shearing strength of the plate while oestrogen increases it. Since oestrogen exerts its effect primarily by inhibiting the secretion of growth-hormone by the anterior pituitary gland rather than by a direct action on the epiphysial plate, it seems that the strength of the plate is dependent ultimately on the balance, or ratio, achieved between the concentrations of these two hormones in the circulation. When this ratio is disturbed in favour of growth-hormone, the epiphysial plates undergo a decrease in shearing strength.

The abnormalities of growth associated with slipping of the upper femoral epiphysis in man suggest that the growth-hormone: sex-hormone ratio has been disturbed in favour of growth-hormone. This could occur in either of two ways: 1) by decreased sex-hormone secretion such as occurs in the adiposo-genital syndrome; or 2) by increased growth-hormone secretion such as occurs in the tall, thin, rapidly growing child. In each case, the actual quantity of each hormone secreted is of relatively little consequence, but the ratio between the two is the all-important factor affecting the shearing strength of the epiphysial plates. Thus, although the amount of growth-hormone secreted in the adiposo-genital syndrome may be less than usual, it is still far in excess of the sex-hormone; and although the amount of sex-hormone secreted in the tall, thin, rapidly growing child may be sufficient to produce secondary sex changes, it is still insufficient to control the already enormous secretion of growth-hormone. In both these disturbances of growth the end-result

is the same: the epiphysial plates come under the predominant influence of growth-hormone and, therefore, undergo a decrease in shearing strength just as occurred in experimental animals. It is probable that every epiphysial plate in the body is similarly affected by this process. But the upper femoral epiphysial plate is alone subjected to shearing during normal weight-bearing and may give way, perhaps after trivial injury which passes unnoticed in the hurly-burly of everyday adolescent life.

Oestrogen was selected for the experiments reported in this paper because it is well known that it produces typical histological changes even when given in relatively small amounts. The action of testosterone is less clear-cut: when given in small amounts it stimulates growth; but when given in large amounts it inhibits growth (Rubinstein *et al.* 1939, 1940). Preliminary experiments on the effect of testosterone on the shearing strength of the epiphysial plates confirm these findings. Testosterone must be given in large amounts, and over a fairly long period of time, before it increases the shearing strength of the epiphysial plates. The proximal tibial epiphysis was chosen because it is the largest in the rat, and because with the exception of the projection for the tibial tuberosity, its epiphysial plate has no irregularities which might interfere with the calculation of its shearing strength.

Summary and Conclusions—1. An apparatus was designed to determine the shearing strength of the upper tibial epiphysis in the rat. Observations were made with this instrument on normal animals, on animals receiving growth-hormone, and on animals receiving oestrogen.
2. When the epiphysis separates from the diaphysis, the plane of cleavage is constant, passing through the third layer of the epiphysial plate.
3. Growth-hormone decreases and sex-hormone increases the shearing strength of the epiphysial plate. These changes are due to alterations produced by these two hormones in the thickness of the third layer of the epiphysial plate.
4. It is suggested that these findings may be of significance in providing an anatomical basis for slipping of the upper femoral epiphysis in man, especially when it is associated with the adiposo-genital syndrome or with rapid adolescent growth.

The author wishes to acknowledge the valuable help and criticism of Professor A. W. Ham in the preparation of this article, and the skilful technical assistance of Miss Marjorie Allen, and of Messrs W. Parry, G. Ross and H. Whittaker. Thanks are also due to Douglas Snair, M.A., of the Department of Physiology, who prepared the growth-hormone, and to the Hoffman-La Roche (Canada) Limited, for the gift of oestradiol benzoate.

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ROTATION-PLASTY FOR CONGENITAL DEFECTS OF THE FEMUR

Making use of the Ankle of the Shortened Limb to Control the Knee Joint of a Prosthesis

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Several varieties of hypoplasia or congenital absence of part of the femur are seen in orthopaedic practice. There may be delayed development and shortening of the whole femur with subluxation of the hip or knee joint (Fig. 1) but sometimes with these joints well developed. In other cases the lower end of the femur may be present but the upper end is luxated and not differentiated into a head and neck (Fig. 2). Finally the middle part of the femur may be absent, the short proximal fragment being abducted and the knee joint

FIG. 1

Delayed development and shortening of the femur with congenital subluxation of the knee joint.

FIG. 2

Failure of development of the upper end of the femur with shortening of the bone and congenital subluxation of the hip joint.

situated just below the hip (Fig. 3). In every type of congenital defect of the femur there is severe shortening of the thigh so that the ankle joint of the short limb is at about the level of the knee joint of the normal side.

To enable these patients to walk we must provide them with an appliance by which to compensate for the shortening. But since the knee joint of the defective limb is situated immediately beneath the hip, and is related to a large mass of muscle, it is seldom possible to allow free mobility of the knee in any prosthesis. Furthermore, since the ankle joint, which is now at the level of the sound knee, permits only a useless range of hyperextension movement, the ankle must also be immobilised. There is no alternative but to fit a leather cuff to the disabled limb with the foot in equinus and to extend the appliance to the necessary length by means of a stilt or other device. It is difficult to fit the leather cuff to the thigh, which is short and thick, so that a pelvic band is often necessary. Thus, finally, the prosthesis

FIG. 3

FIG. 4

FIG. 6

FIG. 5

Case 1. Congenital absence of the middle part of the femur (Fig. 3). The child learned to walk on a pylon (Fig. 4). After fusion of the pseudarthrosis and rotation-plasty, and later tibio-femoral fusion (Fig. 5), she was fitted with a prosthesis with the ankle joint of the shortened limb at the level of the knee (Fig. 6).

is rigid and heavy, and it permits only flexion and extension movement of the hip joint. Walking is difficult and tiresome, particularly since the hip muscles are often imperfectly developed, and the prosthesis itself is unsightly and repellent especially when there is fixed abduction-flexion deformity at the hip. Every patient who is fitted with such an apparatus complains of the difficulties and inconvenience of attempting to travel in public conveyances. We have therefore tried to find other ways of improving the lot of these disabled persons.

The shortening is of such a degree that it cannot be compensated by lengthening the short femur or shortening the long femur. Borggreve (1930) suggested a method of overcoming the main difficulty. In a patient with thirty-five centimetres of shortening of the lower limb due to resection of bone at an early age, he rotated the limb through 180 degrees, so that the heel was directed forwards and the toes backwards. The muscles controlling the ankle of the short limb could then work the knee joint of the prosthesis.

The difficulties I met in applying this idea to cases of shortening from congenital defects of the femur were even greater than those reported by Borggreve. He had only to rotate the leg through 180 degrees, whereas most of my patients also required treatment of the defect in the femur. In the first place it was sometimes necessary to secure union of a pseudarthrosis of the femur. Secondly, it was often impossible to stabilise the knee in its position immediately under the hip joint, in the bulky tissues of the thigh, so that fusion of the knee was necessary. Much of the required rotation of the limb could be gained in these two operations, but if 180 degrees of rotation had not been attained it was necessary finally to perform a rotation osteotomy so that the heel was directed forwards. A combination of these operations has been practised several times at the Anna Kliniek with very satisfactory results. I will describe in detail three patients whose photographic records are complete. All were treated many years ago and the results can now be considered as final.

CASE REPORTS

Case 1. Female, aged 1 year—First seen in 1929, at the age of one year, with considerable shortening of the lower limb from a defect of the shaft of the femur (Fig. 3). The left femur measured 8 centimetres, the right 24 centimetres. The thigh was abducted and flexed 45 degrees. With a walking appliance consisting of a simple leather pylon the patient learned to walk with the hip and knee in slight flexion (Fig. 4). In succeeding years the appliance became increasingly troublesome and it was decided to perform the operation that we have described as "rotation-plasty."

In June 1935 the pseudarthrosis of the femur was exposed. The fragments were freshened and osteosynthesis was carried out. At the same time the lower leg was rotated so that the heel faced forwards. Some months later the patient was given a prosthesis with a knee joint which she moved with the flexors and extensors of the foot (Fig. 6). It was impossible to control the high knee joint and bulky thigh muscles so that arthrodesis of this joint was performed in January 1937 (Fig. 5). The child walked very well with her new apparatus and was able to participate in sports. In the winter of 1940, with much confidence but some imprudence, she engaged in skating and fell, sustaining a fracture of the short femur. This was treated in another hospital, with the result that some rotation was lost. Nevertheless she can still walk several miles, is skilled in housekeeping, is on her feet all day, and intends soon to marry.

Case 2. Female, aged 9 years—This patient attended our out-patient department in 1928, at the age of nine years, with severe shortening of the left lower limb due to a congenital defect of the femur. There was pseudarthrosis of the femoral shaft and the thigh was abducted nearly 90 degrees (Fig. 7). She was supplied with a walking appliance including a pelvic belt. To give good support during walking it was necessary to immobilise all three articulations of the short limb (Fig. 8).

In 1937 she complained of pain in the pseudarthrosis and we decided to perform a rotation-plasty. The first operation was done in May 1937. To correct the flexion-abduction deformity of the thigh, and to raise the foot to the level of the sound knee, the distal part of the femur was excised. The proximal fragment of the femur and the upper part of the tibia were freshened and after rotating the limb through 90 degrees the bones were fixed by two screws. Eight days later we performed a rotation osteotomy of the tibia which brought the heel into the forward position. Some months later the patient was fitted with a prosthesis with a free knee articulation. (Fig. 9). She soon walked very well, moving her new "knee joint" physiologically. A slight limp remained as a result of the weakened hip muscles.

Case 3. Female, aged 15 years—First seen in 1936 with twenty-eight centimetres of shortening of the right lower limb from hypoplasia of the femur (Fig. 10). The ankle was four centimetres below the level of the sound knee joint. She then wore a heavy and rigid prosthesis which enveloped the whole limb (Fig. 11). Walking was difficult and the patient was anxious to have something done. We proposed rotation-plasty and this was performed in September 1939. After resecting four centimetres of bone at the knee, the limb was rotated through 180 degrees and fixed by a Steinmann's pin. Some months later the patient was fitted with a prosthesis with a free knee articulation (Fig. 12). She became accustomed to this apparatus very quickly and now walks normally.

These three patients, all of whom were treated eight to ten years ago, report regularly to our clinic for repair or renewal of their prostheses. We have therefore had the opportunity of reviewing them from time to time, and the late-results have remained excellent. The patients are very satisfied and grateful for the aesthetic, functional and social improvements they have gained. Other cases, operated upon in a similar way in more recent years, have also secured gratifying results but are not presented in detail because, in consequence of war,

FIG. 7

Case 2. Congenital hypoplasia of the femur with pseudarthrosis in the middle third.

FIG. 8

FIG. 9

Case 2. The walking appliance that was originally fitted to the abducted stump immobilised the hip, knee and ankle joints (Fig. 8). After excision of the distal fragment of the femur, fusion of the proximal fragment to the tibia, and rotation-plasty, an artificial limb was fitted with good control at the level of the knee by the rotated ankle joint of the shortened limb (Fig. 9).

FIG. 10

FIG. 11

FIG. 12

Case 3. Congenital hypoplasia of the femur, the ankle joint being 4 centimetres below the level of the sound knee joint (Fig. 10). A heavy and rigid prosthesis had been fitted (Fig. 11). After fusion of the knee with resection of 4 centimetres of bone, and "rotation-plasty" through 180 degrees, a jointed prosthesis was fitted, the ankle joint of the short limb controlling the knee of the prosthesis (Fig. 12).

FIG. 13

FIG. 14

Congenital hypoplasia with very marked shortening of the femur and dislocation of the hip joint (Fig. 13). "Rotation-plasty" with intramedullary nail fixation was combined with reposition of the hip joint with a vitallium cup (Fig. 14).

many of their clinical records and photographs have been destroyed. Intramedullary pin fixation is now used in most cases, thus giving the possibility of sound internal fixation with rotation of the limb at the same time. One such case is shown in Figures 13 and 14. There was hypoplasia of the femur with congenital dislocation of the hip joint. "Rotation-plasty" was performed with intramedullary pin fixation and reposition of the hip with vitallium cup arthroplasty.

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ARTERIOGRAPHY IN BONE TUMOURS

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Our first report on arteriography to the Academy of Surgery in Paris* discussed the value of this technique in studying the patency of blood vessels, and the pattern of vascular systems in the viscera and limbs. Since then it has been our concern not only to determine the anatomical distribution of blood vessels but also the functional circulation of diseased tissues. In these investigations, collaborating with our radiologist, Professor José Caldas, we adopted the technique of serial arteriography. Simple arteriography, by the injection of opaque solutions into the proximal part of the main artery of a limb, gives a picture of the vascular pattern down to the smallest branches at any given moment a few seconds after beginning the injection; but if a series of films is taken at intervals of one, two and three seconds, information of a wider character is made available. It is then possible not only to assess the morphological appearances but also to examine the circulation from a dynamic point of view. Study of the time taken by opaque fluids to pass from the arteries to the veins gives an indication of the speed and activity of the local circulation, and of the extent of communication between the arterial and venous networks.

It was reasonable to suppose that specific lesions of the tissues might be associated with characteristic changes not only in the structural pattern but also in the functional state of the communicating network between arterial and venous systems. It was this concept of the problem that led us to recognise the special significance of arteriography in the study of tumours of soft tissue and bone. Such application of arteriographic methods has been applied not only to vascular lesions but also to many pathological processes in the limbs.

In later reports to the Academy of Surgery in Paris we described developments in the study of osteomyelitis and limb tumours by arteriography. Professor José Caldas published a paper on the same subject. At that time we had investigated thirty-seven limb tumours, thirty malignant and seven benign, of which twenty-two arose in bone; as well as many cases of osteomyelitis, vascular disease, tuberculosis of bone, syphilis of bone and other lesions. The total number of tumours now studied amounts to one hundred. We have gained experience of the arteriographic characteristics of bone tumours and also learned to recognise significant features in their differential diagnosis from osteomyelitis with which they are often confused.

ARTERIOGRAPHIC APPEARANCES IN BONE TUMOURS

To give a clearer understanding of the arteriographic appearances of bone tumours it will be useful first to study arteriograms of a normal limb (Fig. 1) and of tumours of soft tissues (Fig. 2). Sarcomas arising from soft tissues of the thigh show a rich vascular network of hairy appearance arising from the deep femoral artery, together with a tangled mass of new vessels, nearly all of the same diameter. This irregular network of new vessels, running in all directions, reflects the uncontrolled growth of the tumour. Such changes are typical of the proliferative vascular activity that is characteristic of new growths (Fig. 2). In contrast, inflammatory lesions are associated with simple hyperaemia in which the arterial pattern retains an orderly and regular arrangement with successive branches of gradually decreasing diameter—a picture of exaggerated circulatory activity and not of proliferative new growth (Fig. 3). In other examples the vascular network of a tumour, usually a sarcoma, shows multiple dilatations with the formation of "blood pools" which again are a consequence of new tissue formation (Fig. 12).

Apart from these morphological changes, study of the circulatory activity of new growths commands interest. The blood passes almost directly into the veins without the interposition

* DOS SANTOS: Reports to Académie de Chirurgie de Paris, April 24, 1929; April 27, 1932; January 7, 1934.

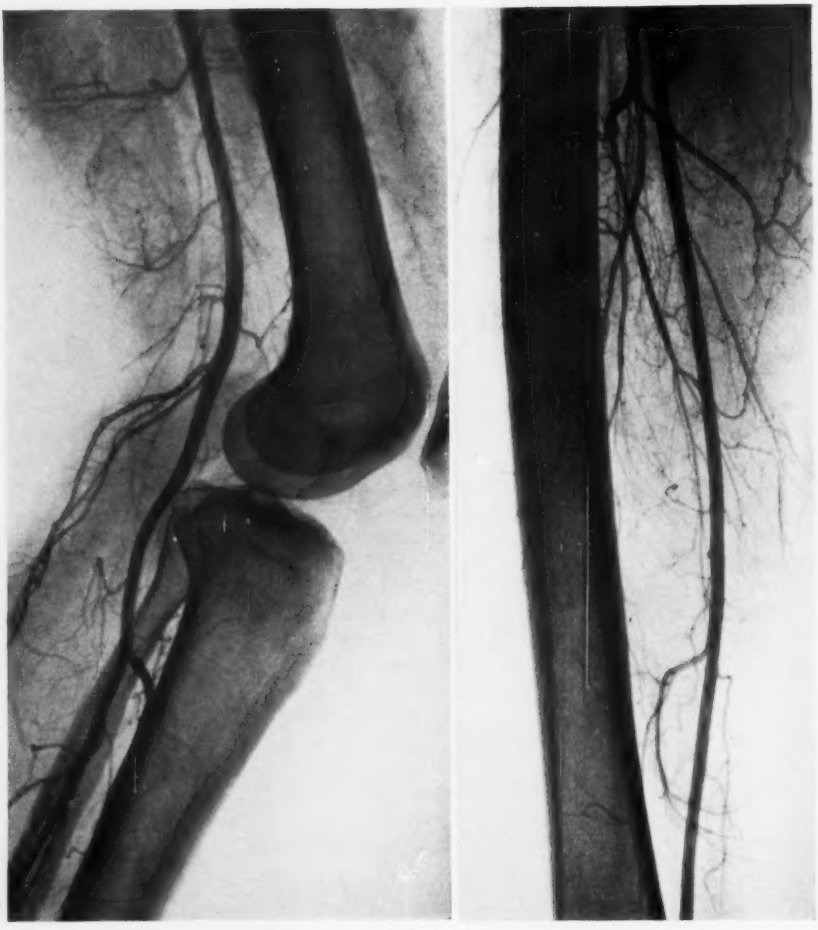

FIG. 1

Normal circulation of the thigh and popliteal area as demonstrated by the injection of thorotrast into the femoral artery. Film taken sixteen seconds after injection.

of capillaries. This is shown in serial arteriograms in which the venous system, and particularly the veins that emerge from the tumour, can be visualised at an unusually early stage. In a normal limb, twenty-two to twenty-four seconds elapse after beginning the injection before the venous system is filled with the contrast medium; but in malignant tumours the passage of blood through the tumour is so rapid that the venous circulation may be shown within fifteen seconds. This increased speed of arterio-venous flow is one of the most constant features of the circulation of tumours, particularly sarcomas of bone and soft tissue. It is clear from arteriographic studies that such increase in vascular activity is confined to the tumour tissue itself: the venous circulation of normal tissues proximal and distal to the tumour shows no increased speed of filling. The first veins to be filled may be seen to arise directly from the tumour itself (Figs. 5 to 10).

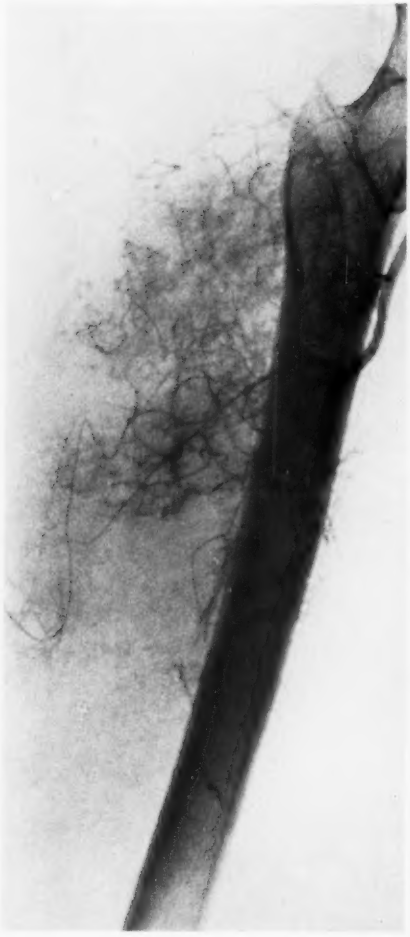

FIG. 2

Sarcoma of the thigh. Note the abnormal and uncontrolled proliferation of new blood vessels.

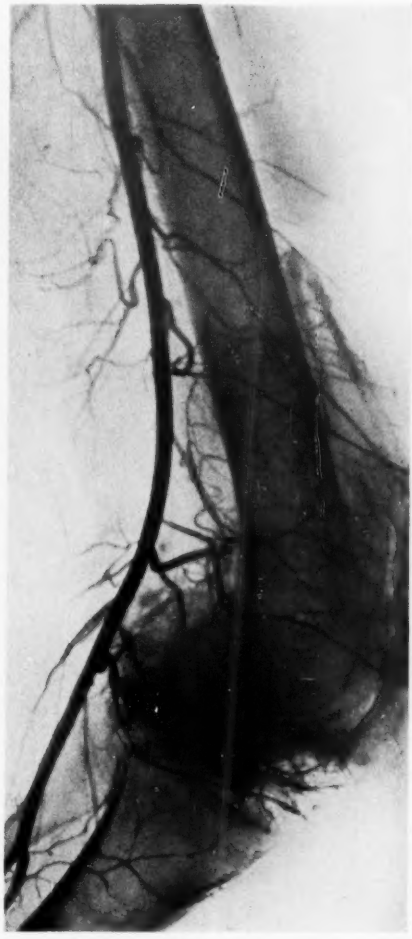

FIG. 3

Tuberculosis of the knee. There is hyperaemia rather than vascular neoplasia.

Moreover the abnormal vascular pattern defines clearly the limits of the tumour, the extent of which is seldom disclosed by routine radiographs (Figs. 24 and 25). Arteriography of bone tumours displays the whole abnormal vascular network and thus makes it possible to measure the degree of invasion of adjacent tissues (Figs. 17 to 20).

The blood pools already mentioned are often seen in osteoclastomas. Filling of the venous tree is less rapid than in sarcomas, this being a sign of relative benignity (Figs. 11 and 12). When thorotrast was used as a contrast medium, radiographic examination one or more months after arteriography showed that the tumour was still impregnated with thorotrast. Thorotrast has the property of selective fixation in the reticulo-endothelial system, and its persistence within the tumour suggests the possibility that reticulo-endothelial cells may play a part in the genesis of osteoclastoma.

FIG. 4

Sarcoma of the soft tissues. Arteriogram fifteen seconds after injection. Note the rich network of new vessels and the abnormally early filling of veins in the region of the tumour (but only in the territory of the tumour).

FIG. 5

Giant-celled sarcoma of the femur, eight seconds after injection.

FIG. 6

Giant-celled sarcoma of the femur, twelve seconds after injection.

Giant-celled sarcoma of the lower end of the femur. Two radiographs from a series of six exposures, one eight seconds after injection and one twelve seconds after injection. Note the abnormally early filling of veins with the contrast medium (Fig. 6).

FIG. 7
Sarcoma of femur, twelve seconds after injection.

FIG. 8
Sarcoma of femur, sixteen seconds after injection.

FIG. 9
Twenty seconds after injection.

FIG. 10
Twenty-four seconds after injection.

Sarcoma of the lower end of the femur. Four of the six exposures taken at twelve seconds, sixteen seconds, twenty seconds and twenty-four seconds after injection. Note the newly formed vessels, invasion of soft tissues and filling of veins even at twelve seconds.

FIG. 11

Osteoclastoma of the lower end of the radius (Fig. 11). The same tumour when demonstrated by arteriography shows blood pools in the neoplastic tissue (Fig. 12). The veins are not filled as they are in sarcomata (compare with Fig. 13).

FIG. 12

FIG. 13

Chondro-sarcoma of the hand with abnormal vascular network and early filling of the veins. Compare this with benign tumours (Fig. 12), in which the veins do not fill quickly.

FIG. 14

Osteomyelitis of the tibia. Arteriography shows ischaemia. Compare with arteriograms of sarcomas of bone.

FIG. 15

Osteomyelitis of the femur. There is no abnormal vascular network or early filling of veins; on the contrary, there is ischaemia.

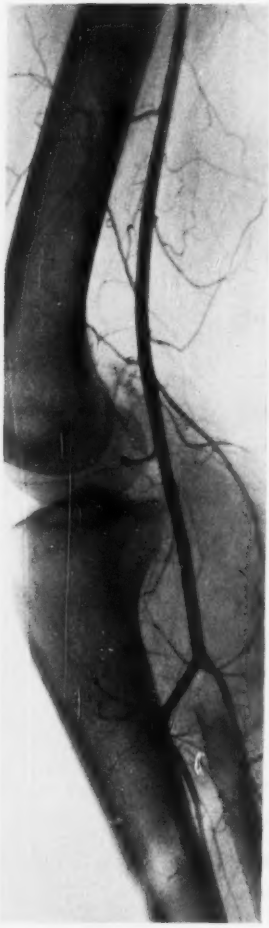

FIG. 16

Benign cyst of the fibula. Arteriograms show that the circulation is almost normal.

FIG. 17

FIG. 18

Ewing's tumour of the shaft of the femur. Routine radiographs (Fig. 17) give little true impression of the extent of the lesion, and on this evidence alone the possibility of osteomyelitis cannot be ruled out. Arteriography reveals the richness of the abnormal circulation, demonstrates the degree of invasion of soft parts, and leaves no possible doubt as to the diagnosis.

FIG. 19

FIG. 20

Osteosarcoma of the tibia in a child with secondary atrophy of the fibula from pressure of the expanding tumour upon it (Fig. 19). Arteriography shows the abnormal vascular network of the tumour; and it demonstrates unduly early filling of the veins (Fig. 20).

FIG. 21
Sarcoma of the radius.

FIG. 22

FIG. 23

Sarcoma of the radius with arteriograms before X-ray therapy (Fig. 22) and after treatment (Fig. 23). Note that after radiotherapy there is almost complete disappearance of the newly formed neoplastic vessels.

FIG. 24

Sarcoma of the ulna.

FIG. 25

FIG. 26

Sarcoma of the upper end of the ulna with arteriograms before treatment (Fig. 25) and after X-ray therapy (Fig. 26). The tumour and the newly formed blood vessels have almost entirely disappeared.

Arteriographic changes in bone tumours such as newly formed vascular networks, gross irregularity of structure, disordered branching of arterioles, and "blood pools" cut in the neoplastic tissues are the changes of *structure* that occur in malignant tumours, particularly sarcomas; whereas changes in the *functional activity* of the local circulation are represented by early visualisation of the veins which is an index of the speed of blood flow through the tumour mass accounting for local increase of temperature and activity of the growth. Arteriography is of value in indicating the extent of the tumour, though obviously the outline which is demonstrated corresponds to the limits of vascular activity rather than the extent of cellular infiltration. Arteriography is a harmless and simple procedure which is fully justified in the differential diagnosis of doubtful neoplasms. Illustrative cases are shown in the radiographs reproduced at the end of this paper.

Applications of arteriography to the diagnosis and treatment of bone tumours—In the differential diagnosis of some bone tumours one of the most difficult problems is the distinction from chronic osteomyelitis. We have therefore made a special study of the arteriographic appearances in chronic osteomyelitis. Arteriograms always show relative ischaemia at the level of the bone lesion, which is in distinct contrast to the newly formed circulation of tumours (Figs. 14 and 15). In many doubtful cases arteriography has made it possible for us to establish a diagnosis which has been confirmed later by histological examination of material removed at operation or biopsy.

Differentiation of malignant from benign tumours—Another problem that arises is the differentiation of malignant from benign tumours. Uncertainty may lead to hesitation in applying treatment, or to inefficient treatment, or perhaps to unnecessarily radical operation. Again arteriography is of value. Whereas in malignant tumours new formation of vessels and early filling of the veins are prominent features, these features are not seen in benign tumours, which are often relatively avascular (Fig. 16). Similarly, arteriography is useful in judging the degree of malignancy of neoplasms. The greater the activity of the tumour, the more pronounced is the new formation of vessels, and the more rapid is the filling of veins.

Assessment of response to irradiation—Finally, arteriography is of value in assessing the response of a tumour to treatment by irradiation. The initial arteriogram usually shows the limits of new vessel formation and the richness of the newly formed network; it may even show distortion of the main vessel by pressure of the tumour (Figs. 22 and 25). After successful irradiation the arteriogram assumes a more normal appearance. The main vessels are restored to their usual positions and the newly formed vascular network may disappear entirely (Figs. 21 to 26). These changes are an index of vascular sclerosis which is one of the factors determining control or retrogression of the tumour. This use of arteriography, as a method of assessing the response to irradiation, is one of its most interesting and useful applications.

SUMMARY

1. Serial arteriograms show not only the anatomical distribution of blood vessels but also the functional state and activity of the peripheral circulation. The technique is of value in the diagnosis of tumours of soft tissues and bone, and particularly in the differential diagnosis of bone tumours from chronic osteomyelitis. It may be used to assess the response of malignant bone tumours to treatment by irradiation.

2. In malignant bone tumours, serial arteriograms show irregular formation of new vessels of uniform diameter, "blood pools," and increased rapidity of flow from the arterial to the venous systems.

3. In osteoclastomas there is new vessel formation and an appearance of "blood pools," but less rapid filling of the veins. In simple tumours there is no new formation of vessels. The tumour itself is often relatively avascular.

4. In osteomyelitis there is no new formation of vessels but only dilatation of existing vessels. The vessels retain their orderly and regular arrangement of successive branches of gradually decreasing diameter.

ACUTE DEPOSITION OF CALCIUM NEAR THE ELBOW

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Deposits of calcium in the common extensor origin of the forearm as described in three cases in this paper are unusual; only nine similar examples have been found in the literature. The main interest lies, however, not so much in the rarity of the lesion as in the clue it may provide to the etiological problems of "tennis elbow." The characteristic symptoms are indistinguishable from those of tennis elbow; there is acute onset of pain, tenderness and swelling in the region of the lateral epicondyle; and radiographs show a dense shadow below the epicondyle. In patients treated by early operation it is evident that this shadow is due to the deposit of a viscous fluid, consisting largely of calcium phosphate, in the origin of the common extensor aponeurosis. With conservative treatment the fluid may absorb rapidly and the acute symptoms may subside, but the more chronic features of tennis elbow tend to persist.

REVIEW OF THE LITERATURE

Schmitt (1921) described such a condition in a woman of thirty-four years with typical radiographic appearances. At operation a collection of doughy material was found deep to the origin of the common extensor muscles. It was shown that the deposit consisted of calcium phosphate and calcium carbonate. Carp (1932) reported five cases. In the first, in a man aged fifty-two years, operation eight weeks after the onset of symptoms disclosed a cavity containing a milky fluid deep to the common tendon of origin of the extensors of the forearm. Microscopically the walls of the space showed chronic inflammation with a few calcareous deposits. In the second patient, a woman aged twenty-five years, conservative treatment was adopted, and within four weeks the symptoms subsided and radiographs showed that the opaque shadow had disappeared. Carp attributed this result to rupture of the wall of the cyst by massage. Two other cases showed similarly acute clinical features and the same spontaneous recovery, but the radiographic shadow had a linear outline like a bony spur. In Carp's fifth case the opacity was small and oval in shape; it had not altered significantly after ten weeks. As the symptoms were chronic and unassociated with swelling the case is not strictly comparable with those now under discussion.

Fiorentini (1937) described four typical cases. Three patients were treated by irradiation, with indifferent results. The fourth was treated by incision through the common extensor tendon; a creamy fluid escaped and the cavity was curetted. Hamilton (1938) reported a patient who was treated by immobilisation for six weeks by which time the symptoms had almost subsided and radiographic examination was negative. The case reported by Young (1944) was treated by irradiation; after six weeks there was evidence of some improvement.

CASE RECORDS

Case 1, female, aged 30 years, typist—Seen on August 25, 1947. Two weeks previously, without apparent cause, there was aching in the left elbow on its lateral aspect. The pain was aggravated by movement of the forearm; it radiated to the dorsum of the hand and fingers. Two days before attending hospital the painful area became swollen and very tender. The pain was increased by pronation and supination of the forearm and by extension of the fingers.

On examination—There was a localised and tender swelling just below the epicondyle (Fig. 1). The overlying skin was warm and oedematous. The elbow was held in flexion. Passive movement was from 170 to 60 degrees. Radiographs showed normal bone contours but there were irregular opacities on the lateral aspect of the joint in close relation to the humerus and radius (Fig. 2). There was no pyrexia. The blood count and erythrocyte sedimentation rate were normal. The Wassermann reaction was negative.

FIG. 1

Case 1. Calcification of the common extensor origin. The local swelling is seen clearly.

FIG. 2

FIG. 3

Case 1. Radiographs at the time of the acute exacerbation show a well-defined area of calcification (Fig. 2). This gradually disappeared under treatment by rest. Figure 3 shows condition at two weeks.

Rest in a sling was advised. After two weeks there was less tenderness and radiographs showed that the density of the opacities was reduced (Fig. 3). Two weeks later the shadows had almost disappeared, and on October 6, six weeks after her first attendance, they could no longer be seen. Nevertheless she still complained of pain and tenderness which persisted with varying severity for many months. Operative treatment was therefore advised.

Operation, March 19, 1948—The common extensor tendon was exposed by a longitudinal incision and divided in the direction of its tendinous fibres 1 centimetre behind the posterior border of the extensor carpi radialis brevis. The subtendinous space between the common tendon and the capsule of the radio-humeral joint was found to be filled with fibrous tissue. This was removed. Within three weeks of operation the symptoms subsided completely and six months later there was no evidence of recurrence.

Case 2, female, aged 29 years—Seen on November 12, 1947, complaining of aching in the region of the lateral epicondyle of the left elbow for eight months. There was no history of injury. The pain radiated down the back of the forearm to the fingers and it was increased by use of the limb. Three days before hospital attendance the arm became acutely painful and stiff, and a swelling appeared on the lateral aspect of the elbow.

Clinical examination—There was diffuse swelling on the lateral aspect of the elbow. The greatest tenderness was immediately below the lateral epicondyle. There was a painless range of movement from 135 to 80 degrees. Pronation and supination were normal. Extension of the middle three digits against gravity and resistance was painful. Radiographs showed an irregular opacity on the lateral aspect of the joint in close relation to the humerus and radius (Fig. 4). There was no pyrexia. The erythrocyte sedimentation rate and blood count were normal. The blood Wassermann reaction was negative.

Operation, November 19, 1947—The tendon of origin of the common forearm extensors was divided in the line of its fibres; a white, opaque, viscous fluid escaped. Examination showed that it occupied a space between the aponeurosis and the capsule of the radio-humeral joint, extending distally from the epicondyle for a distance of 2 centimetres, and anteriorly and posteriorly to the limits of the aponeurosis. Its walls were coated with a white chalky material; the capacity was about 3 cubic centimetres. After evacuation of all the fluid and curettage of the cavity, the skin was closed with interrupted sutures. There was

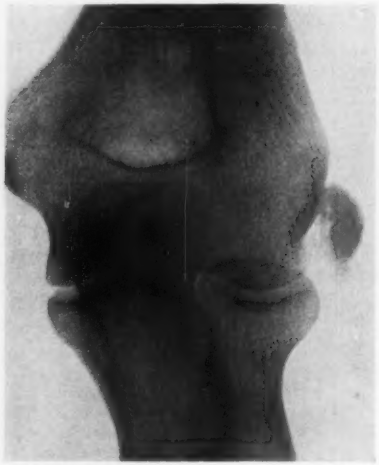

FIG. 4

Case 2. Radiographic appearance at the time of acute exacerbation.

FIG. 5

Case 3. Appearance of the calcified deposit shortly before operation.

immediate relief of symptoms and within three weeks normal function was restored. A year later the left arm differed in no way from the right.

Pathological investigation—Histological examination showed that the wall of the cyst was fibrous, partly necrotic, and infiltrated with calcium salts. There were many lymphocytes and histiocytes. Bacteriological cultures were sterile. Biochemical examination showed that the deposit was largely calcium and phosphate with a little fat and protein (21·3 milligrams calcium, 7·7 milligrams phosphate determined as phosphorus, 34·0 milligrams fat).

Case 3, female, aged 28 years—Seen and treated by Sir Reginald Watson-Jones—Six months' history of pain over the lateral aspect of the right elbow, aggravated by gripping in the right hand and by resisted movements of the forearm. No history of injury.

On examination there was tenderness and slight swelling localised accurately to the common extensor origin immediately below the lateral epicondyle. Radiographic examination showed a calcified deposit on the region of the common extensor origin (Fig. 5). The left elbow and the shoulders were normal.

Operation, July 31, 1942—The common extensor origin was exposed. Within the tendinous fibres there was a yellow-white deposit which was evacuated. It had exactly the same consistency as calcified deposits in the supraspinatus tendon.

Subsequent progress—The pain was at once relieved and after the wound healed full elbow movements were regained within three weeks. Recovery was complete.

DISCUSSION

It was considered by Schmitt that there had been a deposit of calcium phosphate in the walls and lumen of a bursa and this view received the support of Carp, Hamilton and Young. Fiorentini was unable to decide whether the lesion was primarily bursal or tendinous. Between the common tendon of origin of the forearm extensors and the capsule of the radio-humeral joint is a tissue space, bounded proximally by the lateral epicondyle, anteriorly by the origin of the extensor carpi radialis brevis muscle, and posteriorly by the insertion of the anconeus muscle. Normally, this space is occupied by loose areolar tissue. In a series of sixteen operations performed for chronic "tennis elbow" no macroscopic or microscopic abnormality was seen in the common tendon of the forearm extensors. In two cases the space under this tendon contained a small thick-walled bursal sac (Fig. 6); in the others it was obliterated by tissue which microscopically resembled the pannus found in larger bursae and in joints. Removal of this tissue afforded immediate and apparently permanent relief. These observations are in close agreement with those of Osgood (1922).

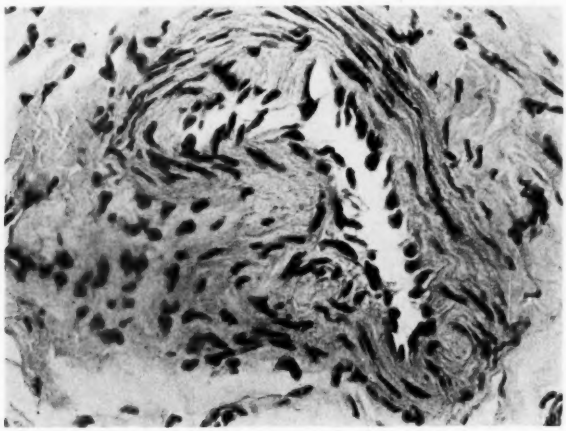

FIG. 6

Chronic "tennis elbow," four months duration. Section shows the walls of the bursa 0·4 centimetres × 0·4 centimetres, which lay deep to the tendon of origin of the forearm extensors.

The condition now described resembles very closely that which involves the insertion of the supraspinatus tendon. In both there is an acute attack of pain with limitation of movement superimposed upon a preceding chronic stage and radiographic evidence of a dense irregular shadow. Treated conservatively, the deposit may gradually absorb with corresponding relief of pain. Operation in each condition reveals a deposit of thick opaque fluid. Biochemical analysis in the cases now reported showed calcium and phosphate in proportions comparable to that found by Elmslie (1932) in material removed from the supraspinatus tendon.

Whatever treatment is adopted for calcification in the region of the elbow, whether by rest, irradiation or massage, the deposit seems to be absorbed rapidly; the acute exacerbation subsides and sometimes even chronic symptoms may be relieved. Nevertheless conservative treatment is time-consuming and there is often persistent discomfort. Operation has proved successful and it is the treatment of choice. All that is necessary is to incise the tendon of origin of the common forearm extensors in the line of its fibres, remove the calcified material, curette the walls of the cavity and encourage active exercises after operation.

SUMMARY

1. Three cases of localised deposition of calcium salts deep to the origin of the common extensors of the forearm with acute symptoms clinically indistinguishable from " tennis elbow " are described.
2. Reports of nine similar cases have been found in the literature.
3. It is suggested that " tennis elbow " is caused by a lesion, probably an adventitial bursa, in the tissue space between the tendon of origin of the forearm extensors and the capsule of the radio-humeral joint; and that it is the sudden precipitation of calcium phosphate at this site which causes the lesion here described.
4. Acute calcification near the elbow joint is compared with the similar calcification which may occur in the insertion of the supraspinatus tendon.
5. Operative treatment is advised.

I am indebted to Mr Charles Gray for his permission to treat and publish Case 2 and for his helpful criticisms of this paper. Case 3 is published by kind permission of Sir Reginald Watson-Jones, to whom my thanks are due. I wish to thank Dr C. V. Harrison for examining the operation specimens.

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FRACTURE-SEPARATION OF THE PROXIMAL EPIPHYSIS OF THE HUMERUS

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Fracture-separation of the proximal epiphysis of the humerus is an unusual injury of childhood and adolescence which may occur also as a birth injury. As with other epiphysial fracture-separations a fragment of diaphysis remains attached to the epiphysis and the stability after reduction depends largely upon the size of the attached diaphysial fragment. When this is small the reduced position is relatively stable; but when the fragment is large the displacement is both difficult to reduce and unstable after reduction. In this paper a method of reduction and fixation is presented. It is illustrated by four case reports and, for comparison, a fifth case is reported in which reduction was not undertaken. In all five cases there was a large diaphysial fragment.

Review of literature—Eighteen examples of this injury have been described by Roche (1926), Divis (1927), Zanoli (1928) and Aitken (1936). In ten of these patients the age was recorded as varying from thirteen to nineteen years, and this was the range of age of all five patients in the series now reported. Few details are given of the methods of treatment. Divis described one patient in whom reduction of the fracture was stable after manipulation; the radiographs showed a small attached diaphysial fragment. Aitken reported eleven cases: in two, after repeated unsuccessful manipulations, open reduction and internal fixation was performed; in no case was there permanent deformity; bowing persisted " for the first few months only "; there was shortening in seven cases, varying from one-quarter of an inch to one and a quarter inches. Zanoli in reporting 1,110 fractures of the upper limbs found five fracture-separations among a total of 162 fractures of the proximal end of the humerus which included thirty-five fractures in patients under the age of twenty years.

Mechanics of the injury—No discussion of the mechanism of the injury has been found in previous papers but from three patients in this series a clear history was gained. All three fell backwards on to the hand with the elbow extended and the arm behind the coronal plane, thus suggesting that strain on the proximal end of the humerus included compression, hyperextension and lateral rotation. It was reasonable to suppose, therefore, that reduction might be achieved by traction, flexion and medial rotation. This was tried and it proved successful, though it must be emphasized that considerable force was often needed. It was also found that if flexion and medial rotation were maintained, reduction remained stable after the traction was released. The limb was therefore immobilised in a plaster spica with the shoulder in a position of flexion and medial rotation.

CASE REPORTS

Case 1. Schoolboy, aged 15 years—Initial displacement severe—30 degrees angulation in the antero-posterior radiograph and 18 degrees in the lateral radiograph. Reduced on the day of injury; immobilised in a plaster spica for six and a half weeks. After removal of the plaster the limb could be lowered to within 30 degrees of the side and was supported in a sling with a large axillary pad of wool. Four weeks later there was slight limitation of adduction and medial rotation; other movements were full. Twenty months after injury there was no limitation of movement, no shortening and no disability. The radiographic appearances were indistinguishable from normal.

Case 2. Male, aged 18 years—Displacement moderate—12 degrees angulation in the antero-posterior radiograph and 23 degrees in the lateral radiograph. Reduced and immobilised on the day of injury. The patient was then transferred to another hospital where the plaster was removed after fourteen days and the arm " pulled down " across the chest; this was described as being very painful. Later radiographs showed recurrence of the original displacement. Four months after injury there was still pain at the extremes of movement. At six months the range of movement was full but there was a quarter-inch of shortening and radiographs showed union with some angulation and distortion of the humerus.

Case 3. Schoolboy, aged 13 years—Displacement moderate—30 degrees angulation in the antero-posterior radiograph. Reduced on the day of injury and immobilised in plaster for six and a half weeks. Two weeks after removal of plaster there was slight limitation of medial rotation. Other movements were full and painless. Three months after injury the radiographs showed union in perfect alignment with minimal thickening and no shortening. At six months there was a full range of movement, no shortening and no disability. Radiographs showed slight irregularity of the diaphysis but the epiphysial line remained unfused.

Case 4. Schoolboy, aged 16 years—Displacement severe—60 degrees of angulation in the lateral radiograph (Fig. 1). Reduced on the day of injury and immobilised in a plaster spica for thirty days. After removal of the plaster the limb was supported on an abduction splint. After four days the patient removed the splint; he found he could get the limb to his side in comfort. Five weeks after injury radiographs showed union in perfect alignment (Fig. 2). Eight weeks after injury there was no limitation of movement, no shortening and no pain. Power was almost normal.

FIG. 1

FIG. 2

Case 4. Fracture-separation of the upper humeral epiphysis with displacement and angulation (Fig. 1). Reduction was achieved by traction on the limb in the position of flexion and medial rotation. Radiography five weeks later show that the reduction has been maintained (Fig. 2).

Case 5. Female, aged 13 years—Displacement apparently slight. Only an antero-posterior radiograph was taken and this showed angulation of 10 degrees. Reduction was not attempted. The limb was supported in a sling and active movements were encouraged. Two years after injury there was a full range of movement and no symptoms other than occasional aching. Radiographs showed persistent angulation of the humerus—15 degrees in the antero-posterior view, 30 degrees in the lateral view. The apex of the angle was one and three-quarter inches from the epiphysial line. The epiphysis was still incompletely fused to the shaft. This case illustrates the necessity for radiographs in two planes at right angles. The original assessment of angulation as 10 degrees, based on the antero-posterior projection alone, was misleading.

Technique of reduction—The patient is anaesthetised and placed on his back. An assistant holds the shoulders level and presses upwards on the head of the humerus to prevent dislocation of the shoulder joint. The operator applies traction to the limb and brings it into

a position of medial rotation and forward flexion; with the elbow at a right angle, the hand is then above and in front of the eye of the opposite side with the thumb pointing directly downwards (Fig. 3). It is usually necessary to press hard on the proximal end of the distal fragment. Once achieved, reduction is stable if the position of nearly full flexion and medial rotation is maintained. Radiographic confirmation of reduction before application of the plaster spica is advisable because it is difficult to determine clinically whether or not complete reduction has been gained. The plaster must fit snugly over the shoulder and the acromion and clavicle should be protected by a felt pad.

FIG. 3

After reduction the limb is immobilised in a position of flexion and medial rotation.

Discussion—Fracture-separation of the proximal epiphysis of the humerus often causes little disability even if the displacement is not reduced, but there may be shortening of the limb, sometimes exceeding one inch, due to angulation of the fragments or premature fusion of the epiphysis. Aitken (1936) described shortening in seven of eleven cases and in this series there was slight shortening in two cases. Such shortening may be avoided by correcting the angulation without increasing the epiphysial injury. This can be achieved by traction on the limb in the position of medial rotation and forward flexion, and if there is gross angulation and displacement such manipulation is advisable. The suggestion of Aitken that uncorrected bowing is corrected "after a few months" has not been borne out in this series. In one case the bowing was still obvious after two years.

SUMMARY

Five cases of fracture-separation of the proximal epiphysis of the humerus are recorded. A method of reduction and immobilisation is described, and the literature is reviewed.

I wish to express my thanks to Mr R. Weeden Butler for much helpful advice and criticism.

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A CASE OF ENGELMANN'S DISEASE

Progressive Diaphysial Dysplasia

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The patient, a man aged twenty-eight, has been in our care for three and a half years. He stated that he has always been thin and weak as compared with others of his own age, but that his height has never been below average. He began to walk at the same age as other children but has always had a waddling gait. During childhood he avoided games because he was easily hurt and after running a few yards developed pain in the legs. The degree of weakness has remained unchanged throughout his life. For the last four years he has suffered from pulmonary tuberculosis which is controlled by artificial pneumothorax. There is no family history of skeletal disease.

FIG. 1

FIG. 2

Engelmann's disease. The enormous thickening of the shafts of the long bones, seen here in the radius and ulna (Fig. 1), and in the tibia and fibula (Fig. 2), is very striking. Other long bones were similarly affected.

Examination showed him to be a tall, loose-limbed individual with generalised underdevelopment and weakness of the muscles particularly around the pelvic girdle and thighs. The lower limbs were bowed and the lumbar spine lordotic. There was no pseudohypertrophy or fibrillation; no sign of congenital syphilis; and no abnormality of the visual fields, tendon reflexes, sexual development or intelligence. Blood chemistry was normal and the Wassermann reaction negative. Bone from the upper third of the left tibia shaft showed normal structure.

Radiography showed appearances similar to those described by Sear (1948) and by Neuhauser, Shwachman, Wittenborg and Cohen (1948). The femora and humeri showed symmetrical thickening of the compact bone of the shafts, the bones being widened, the surfaces slightly irregular and the medullary cavity narrowed. A number of small cystic areas were present in the compact bone. The ends of the bones appeared normal and the epiphyses were united. The radius and ulna, and the tibia and fibula, on both sides showed similar changes, but appeared normal in their distal thirds (Figs. 1 and 2). The skull showed coarse sclerotic patches in the base and vault, especially in the frontal and occipital regions, but the parietal bones were relatively unaffected (Fig. 3). The ribs were large, but their structure was unaltered. The facial bones, clavicles and other bones of the skeleton appeared normal.

FIG. 3
The skull, showing sclerotic thickening mainly affecting the base and the frontal and occipital bones.

Comment--Reports of six other cases have been found in the literature, the first being described by Engelmann in 1929, one by Sear in 1948, and four by Neuhauser, Schwachman, Wittenborg and Cohen in 1948.* The case now reported is the first record of a patient with this disease in the third decade, and it is of interest to note that no material change has occurred in the radiographic appearances during the three and a half years that he has been under observation. The radiographs in Engelmann's patient, a boy aged eight years, showed similar thickening and sclerosis of the diaphyses of all the long bones, and thickened patches in the skull, especially in the frontal bone and the bones of the anterior and middle cranial fossae. The structure of the other bones appeared normal. Clinically, the outstanding feature of our case was the gross muscular under-development and weakness, which was similar in many respects to that of a primary muscular dystrophy.

We wish to thank Dr R. Linton, Medical Superintendent, Musgrave Park Hospital, Belfast, for permission to publish this case.

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* Since this paper was submitted for publication one other case of Engelmann's disease has been reported in a woman, aged twenty-four years, by Michaelis, L. S. (April 1949), Proceedings of the Royal Society of Medicine, **42,** 271 (Orthopaedic Section, p. 11).

CHORDOMA OF THE THIRD LUMBAR VERTEBRA

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Chordomata usually occur either in the base of the skull or in the sacro-coccygeal region. A chordoma arising in the third lumbar vertebra is sufficiently unusual to be worth recording, especially as this case provides also an opportunity to emphasize the value of biopsy in obscure lesions of the vertebrae.

A man aged sixty-four was first seen in February 1947. He complained of pain in the lumbar region which had been present for a number of years but had been much worse during the last two years after a fall when he sat heavily from the standing position.

On examination he was very thin. His complexion was of an earthy hue and his skin was dry. The dorsal and lumbar regions of the spine were fixed in a continuous C curve. There

FIG. 1
Chordoma of the third lumbar vertebra. Extensive destruction is seen in the lateral radiograph.

was wasting of the lower limb muscles. The deep reflexes were depressed. There were no other abnormal physical signs. Examination of the chest, abdomen, pelvis and the rest of the body revealed no signs of abnormality. Radiographs of the dorsal spine showed marked osteoarthritic changes and wedging of a number of vertebral bodies as in old-standing Scheuermann's disease. The changes in the lumbar spine are shown in Figure 1, and on the basis of these radiographic appearances a diagnosis was made of secondary deposit from a malignant tumour.

When seen again in March 1948 his general appearance was much as it had been a year previously. He complained that the pain in his back was worse and his legs were so weak that he could hardly stand. Examination showed increased kyphosis of the lumbar spine. The muscles of the lower limbs were wasted and weak but no muscle was paralysed. The knee jerks and ankle jerks could not be elicited and the plantar responses were equivocal. There was no demonstrable area of cutaneous sensory loss but he said that his legs felt numb

and that sensation was less acute below the level of the knee joints. There was loss of joint sensation in the toes. Radiographs showed increased destruction of bone.

Biopsy was performed through a left paravertebral incision. The left transverse process of the third lumbar vertebra was exposed and resected; this afforded excellent access to the body of the third lumbar vertebra which was found to have been replaced by friable red-brown vascular tissue interspersed with small fragments of bone. On histological examination the tumour was considered by Professor H. L. Sheehan to be a chordoma (Fig. 2).

The pain, which had been severe from the beginning, became so unbearable that the patient and his relatives, though fully realising the risk, begged that something should be done. The tumour was therefore exposed through a right paravertebral incision. Rather unexpectedly a large extra-vertebral mass was found, roughly spherical in shape, two and a

FIG. 2
Chordoma of the third lumbar vertebra. Histological section from biopsy material (×75).

half inches in diameter, of rubbery consistency, apparently encapsulated, pushing forwards the peritoneum, ureter, abdominal organs, aorta and inferior vena cava. To obtain adequate exposure it was necessary to make a further transverse incision in the muscles of the abdominal wall extending laterally from the vertical incision. This gave excellent access and the greater part of the tumour was excised. The third right lumbar nerve was sacrificed. A few days after operation the patient's condition was good; sphincter function remained unimpaired and the condition of the lower limbs was unchanged. Two weeks later he collapsed and died.

Comment—It is felt that if the biopsy had been performed earlier the chances of success would have been greater. In view of the ease with which the lateral aspect of a vertebra can be approached it is suggested that doubtful lesions should be investigated in this way at the earliest possible moment.

NEONATAL SCIATIC PALSY*

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There are few references in the literature to congenital paralysis of the sciatic or popliteal nerves and there are no reports of the condition about to be described. Hugo Ehrenfest in his monograph, " Birth Injuries of the Child," stated that " Bernherdt observed several cases of palsy in the area of distribution of the sciatic nerve after extraction by the foot," and added that " Bruns expressed the opinion that circumscribed paralyses of the lower extremity of new-born infants are probably not uncommon but are overlooked or not reported because they are likely to disappear promptly." Michaëlis (1931) reported the case of a child aged six weeks, who had complete paralysis of the lateral popliteal nerve from birth; the delivery was said to have been normal and no conclusion was reached as to the cause. Meyer (1931) described three cases of paralysis of the lower limbs at birth—one from purulent meningitis which proved fatal, one associated with birth fracture of the femoral shaft, and another which was attributed to traction on the limb during breech delivery.

Lust and Berrewaerts (1932) reported the case of a child who was delivered by lower segment Caesarean section after the mother had been in labour for twenty-four hours. The pelvis was contracted. The child was healthy but the right foot was swollen and there was a complete lesion of the lateral popliteal nerve which recovered in twenty days. In searching for the cause, and having considered all types of birth palsy of the upper limb, they concluded that this was " a case of obstetrical paralysis due to faulty intra-uterine position with compression," thus explaining the oedema of the foot which did not occur in paralysis of the upper limb.

In the report now presented, eleven infants with congenital or neonatal sciatic paralysis are described and it is believed that the cause may have been direct intra-uterine pressure on the sciatic nerve trunk. The part played by intra-uterine pressure in causing deformity has been accepted by some and rejected by others; but in these eleven cases there does seem to have been evidence that intra-uterine pressure was the important factor in causing paralysis of the sciatic nerve.

The infants, six male and five female, were all born at Walton Hospital, Liverpool, between April 1945 and January 1948. They were full-term babies of normal birth-weight, averaging just over seven pounds, the smallest weighing five pounds eleven ounces. There was variation in the severity of the paralysis, but a certain uniformity in the history and clinical findings was noted. There was no evidence of a familial tendency and no history in the mothers of disease or previous abortion, most of them being healthy primipara. The labour was sometimes prolonged and there was usually obstetric interference in the second stage. In all cases a normal placenta was expelled spontaneously.

At birth the child was in a state of asphyxia livida or pallida, responding slowly to clearing of the air passages and the injection of analeptics into the umbilical cord. These measures were sometimes supplemented by mouth-to-mouth breathing and the injection of analeptics into the buttock; but it should be emphasized that in no case was there paralysis of the sciatic nerve on the side of an injection into the buttock. On examination, one lower extremity was seen to be limp and the buttock usually showed a bruise. The paralysis was always of the peripheral type, none showing spastic paralysis or a progressive nerve lesion. In none was there spina bifida. The day after delivery the infant was quite healthy but sometimes the buttock and thigh showed marked oedema in the area surrounding the bruise. Radiographs showed no evidence of fracture. During the next week the oedema subsided and the bruise

* Received for publication, May 1948. (See Editorial.)

became dry and black, separating as a slough on the seventh or eighth day and revealing a clean granulating base which healed to form a scar in about five weeks. There were often signs of recovery in the paralysis during the first week, shown by increasing power in the hamstring and calf muscles, but the lesion of the lateral popliteal division usually remained complete.

CASE REPORTS

Case 1 J. F., male—Born August 21, 1947; full term; weight 8 lb. 4 oz.; first child of healthy mother twenty-four years of age. *Labour*—normal L.O.A.; first stage seven hours; second stage one and a half hours; episiotomy performed. *Baby*—mild asphyxia livida. Sixth day—flaccid left foot noted. Fourteenth day—slight power of dorsiflexion of the ankle; calf muscles fully recovered. Sixth month—full recovery; foot, leg and buttock normal in size and appearance.

Case 2. P. L., male—Born October 27, 1947; full term; weight 8 lb. 1 oz.; first child of healthy mother twenty-seven years of age. *Labour*—normal L.O.A.; first stage thirty hours, second stage three hours. *Baby*—asphyxia pallida, cord tightly round the neck; right leg noted to be white and flaccid, thigh blue, limb colder than the left. Fourteenth day—calf muscles contracting. Fourth month—full recovery; foot, leg and buttock normal in size and appearance.

Case 3. P. O., female—Born July 4, 1946; full term; weight 6 lb. 7 oz.; first child of healthy mother twenty-four years of age. *Labour*—normal L.O.A. by midwife; first stage ten hours; second stage half an hour. *Baby*—mild asphyxia livida. Sixth day—found to have swollen left foot and complete peroneal nerve lesion. Nineteenth month—power present in all affected muscles, acting against gravity but not against resistance; sensation impaired; buttock normal; limb half an inch short and small; foot small; walks well.

Case 4. A. R., female—Born September 22, 1946; full term; weight 6 lb. 7 oz.; first child of healthy mother twenty-six years of age. *Labour*—normal L.O.A.; first stage eighteen hours, second stage three hours. *Baby*—asphyxia pallida. Second day—found to have flail left foot which was smaller than the right. Second month—complete peroneal nerve lesion; recovery in calf muscles. Seventeenth month—palpable flicker and faradic response in tibialis anterior and peronei, but no active movement against gravity; sensation impaired in peroneal area; buttock normal; limb small; foot small; three-quarters of an inch shortening; walks well.

Case 5. B. A., female—Born February 25, 1946; full term; weight 6 lb. 4 oz.; first child of healthy mother twenty-five years of age. *Labour*—L.O.A.; first stage five hours; second stage two hours; foetal heart irregular during the last hour; forceps delivery. *Baby*—severe asphyxia livida. Fifth day—flaccid right foot noted. One month—full recovery in calf muscles, complete peroneal nerve lesion. Two years—active flicker of power and faradic response in all affected muscles but no power against resistance; equino-cavus deformity; sensation impaired; buttock normal; limb pink, small and half an inch short; walks well.

Case 6. L. S., female—Born October 29, 1946; full term; weight 6 lb. 4 oz.; first child of healthy mother twenty-eight years of age. *Labour*—R.O.T.; first stage forty-six hours; second stage six hours with no progress; foetal heart 96/min.; forceps delivery. *Baby*—severe asphyxia livida; purple spots over legs and abdomen; right leg paralysed at birth. Eighth day—foot and leg below the knee flaccid. One month—recovery in calf muscles but complete peroneal nerve lesion. Sixteen months—active flicker of power and faradic response in the tibialis anterior, extensor digitorum longus and peronei, but no power against gravity; sensation impaired; buttock normal; limb small and half an inch short; foot small.

Case 7. P. H., male—Born November 7, 1945; full term; weight 7 lb.; sixth child of healthy mother thirty-three years of age; other children alive and well. *Labour*—L.O.A.; lateral placenta praevia; spontaneous delivery; first stage five hours; second stage half an hour. *Baby*—severe asphyxia livida; right leg blue and weak. Second day—right buttock bruised and right leg completely flaccid. Fourth day—right buttock showed blackened area surrounded by induration. Seventh day—right buttock showed slough quarter of an inch in diameter; movements of right lower limb returning. Twenty-fourth day—right buttock healed; complete peroneal nerve lesion; recovery in calf muscles. Fourth month—slight power of dorsiflexion against gravity in foot. Sixth month—recovery complete; small scar on right buttock; leg and foot normal in size and appearance.

Case 8. P. B., female—Born June 7, 1947; full term; weight 6 lb. 10 oz.; first child of healthy mother thirty-three years of age. *Labour*—P.O.P.; first stage five hours; second stage four hours; foetal heart slow and irregular in second stage; spontaneous delivery. *Baby*—mild asphyxia livida; bruising of the vulva and weakness of the ankle. Third day—hard swelling and mottling of left buttock extending to the vulva; left foot completely flaccid. Eighth day—left buttock ulcerated where a slough had separated; paralysis unchanged. Twenty-sixth day—buttock almost healed; complete peroneal nerve lesion; calf muscles recovered. Eighth month—slight flicker in tibialis anterior and extensor digitorum longus but no response to faradism; no power against gravity in any of the affected muscles; sensation absent in peroneal area; left buttock showed pink contracted scar; left lower limb small and half an inch short; left foot small; learning to walk.

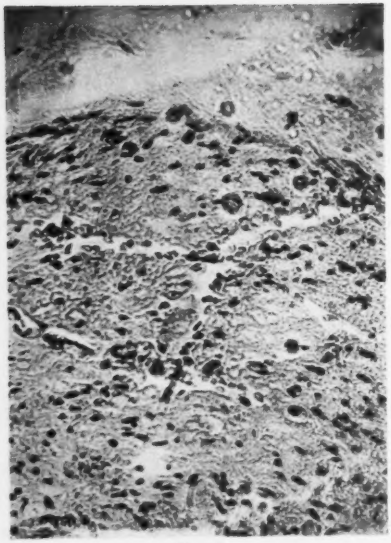

FIG. 1

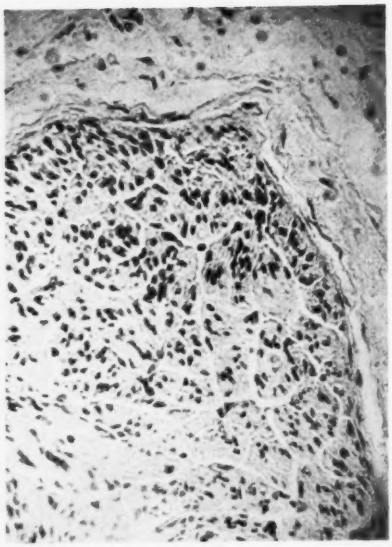

FIG. 2

Figure 1 is a section of the sciatic nerve from the centre of the compressed area over the sacro-tuberous ligament, showing a fasciculus with almost complete loss of nuclear staining in the central parts of the bundle with very few blood cells seen either within vessel walls or in the tissue spaces. Compare with Figure 2 which is a section of a normal sciatic nerve at the same level.

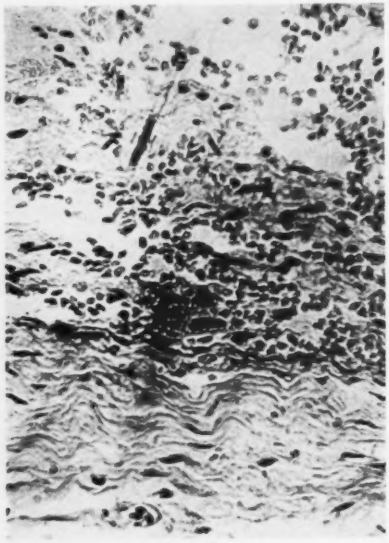

FIG. 3

Section of the sciatic nerve from the level of transition between the compressed area and the normal nerve, showing fragmentation and haemorrhage in a fasciculus.

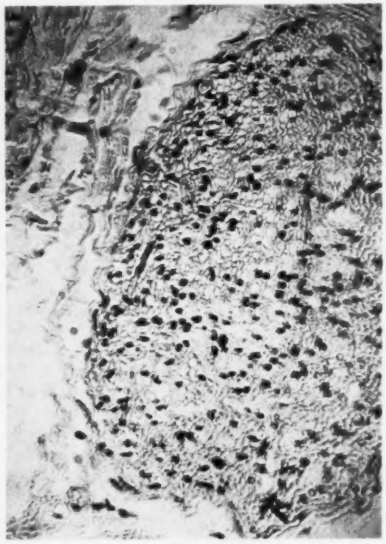

FIG. 4

Section of the affected nerve at the mid-thigh. The vascularity and nuclear staining are normal. The perineurium is thrown into folds from post-natal oedema.

Case 9. J. L., male—Born November 2, 1945; full term; weight 5 lb. 13 oz.; fifth child of healthy mother thirty-three years of age; all alive and well. *Labour*—transverse lie with shoulder presentation; external version and breech delivery; head delivered with difficulty by Burns' method; in labour sixteen hours. *Baby*—mild asphyxia livida; anus, left leg and foot very bruised at birth. Third day—left leg paralysed; extreme swelling and bruising of left buttock and thigh. Seventh day—skin of medial aspect upper thigh sloughing; swelling diminishing. Thirteenth day—moving knee and hip but foot still flail. Eighth week—sloughed area of thigh healed; nerve lesion now limited to peroneal distribution, but complete. Two years—faradic response in all affected muscles but no active movement; sensation absent in peroneal area; left thigh showed contracted scar of upper adductor region extending to the left buttock; left lower limb three-quarters of an inch short, small and pink; left foot small; walking well.

Case 10. C. B., male—Born April 4, 1945; full term; weight 9 lb. 8 oz.; fourth child of healthy mother thirty-three years of age. Second child stillborn, others alive and well. *Labour*—lower segment Caesarean section after forty-eight hours labour without engagement of the head; delivered easily. *Baby*—mild asphyxia livida. Second day—bruised area on left buttock; left leg flaccid. Eleventh day—large slough separated from left buttock leaving a clean granulating surface. Eighth week—buttock healed, calf muscles recovered; complete peroneal nerve lesion. Two years, nine months—faradic response and active movements against gravity in all affected muscles; sensation normal; contracted scar on left buttock; left lower limb one quarter inch short, small and of normal colour; left foot small; walking well.

Case 11. B. W., male—Born January 31, 1948; full term; weight 7 lb. 7 oz.; first child of healthy mother twenty-seven years of age. *Labour*—normal L.O.A.; spontaneous delivery by midwife. *Baby*—asphyxia pallida; cord tightly round the neck; mottled bluish area left buttock. Second day—left thigh markedly swollen; blue area unchanged. Third day—marked oedema of upper two-thirds of left thigh including the buttock, perineum and lower abdomen; thigh aspirated for pus, none found; leg and foot completely flaccid except for weak quadriceps power. Fifth day—oedema of thigh less; mottled area on buttock turning black; the child went steadily downhill, developing watery stools, taking no feeds by mouth, and becoming severely dehydrated; no improvement in the nerve lesion. Twelfth day—died. *Autopsy report* (Dr F. E. D. Griffiths)—Dehydrated infant; oedema of right leg and thigh; on the right buttock was a square patch of black necrotic skin, 2 × 2 centimetres; surrounding the dead skin was a narrow hyperaemic zone; no underlying infection was discovered and apart from grey discolouration of the fat the subcutaneous tissues and underlying muscle appeared normal. On cutting through the gluteus maximus immediately beneath the skin-slough a segment of the sciatic nerve about 1 centimetre in length was seen to have a dull blue tinge in contra-distinction to the normal pink sheen displayed above and below, and it had a distinct appearance of flattening. On palpating the nerve along its course from the sciatic notch the bed on which it lay was found to yield to pressure as would be expected, but when the dull area was pressed upon, it was found to overlie a comparatively rigid structure. This point of resistance proved to be the sacro-tuberous ligament. The opposite side was investigated and, although a similar resistance was felt at the point where the nerve crossed the ligament, no abnormality in the local appearance of the nerve was noted. When the nerve on the affected side was dissected from the spinal cord to the knee the appearance of local flattening was more marked. Seen from the side, the nerve trunk showed obvious thinning, and its sides were tapered to a distinct edge instead of being rounded. The normal nerve showed relatively slight local flattening with gradual transition to the oval shape above and below, in contrast with the sharply demarcated compressed area in the affected nerve. No thrombosed vessels were observed. The spinal canal and cord were normal. There was no osteomyelitis of the surrounding bones. Heart—normal, no congenital defects. Lungs—aerated, no consolidation. Middle ears—dry. Liver—fatty, yellow in colour. Spleen—normal in size and appearance. Stomach and intestine—normal. Kidneys—normal in size, medullary congestion. Other organs—normal. Conclusions—toxaemia and dehydration. Lesion of the sciatic nerve, possibly due to pressure.

Microscopic report—Pieces of the sciatic nerve were fixed in formalin and sections were stained with haematoxylin and eosin. Transverse sections at the level of the lesion showed small recent haemorrhages; there was no exudate of inflammatory cells but there was some disintegration of the fasciculi with loss of nuclear staining mainly towards the centre (Figs. 1 and 2). Sections distal to the lesion showed none of these changes; the margins of the fasiculi were wavy and irregular, suggesting some shrinking (Fig. 4).

DISCUSSION

The obstetrical significance of the lesion under discussion is beyond the province of this paper but it is to be noted that there was no evidence of failure in obstetric treatment either before or immediately after birth.

The slough—It is difficult to explain the presence of a local skin slough such as that found in Case 11 except on the basis of direct pressure lasting for several hours. Since these investigations were begun, three cases of sloughing of the skin in infants within a week of

birth have been examined. In one, there was a linear slough over the lower five dorsal spinous processes; in another the slough was over the sacrum; and in the third, it involved the antero-lateral prominence of a club foot. Since these sloughs were single, and not localised constantly to a specific area, it is difficult to believe that they could be the consequence of general excess of intra-uterine pressure. It is more likely that some small, freely movable structure inside the uterus—possible a foetal hand—might have exerted pressure against a foetal prominence through the agency of general uterine contraction; and that this mechanism could act in the presence of normal uterine pressure by focusing it upon one small area. The hand might well impinge against the buttock, the sacrum or even the lower dorsal spinous processes. Moreover it is possible that such manifestations could occur without obvious effect on the misplaced hand which has so rich a blood supply.

The delivery—Observations suggest that the obstetrical position of the foetus has no bearing on the incidence of sciatic palsy. Of the four patients with right-sided lesions the presentation at labour was L.O.A. in three and R.O.T. in one. When the lesion was on the left side the presentation was L.O.A. in five and R.O.P. in one; and in one there was a transverse lie. It seems unlikely, therefore, that there was pressure from an extra-uterine structure such as a maternal bony prominence because if this had been the cause, the foetal presentation would have borne a constant relationship to the side of the body affected. There was no clinical evidence of pressure from fibroids or other uterine abnormalities.

Course of labour—Two labours were uncomplicated and were handled by midwives; nine required the attendance of an obstetrician. Two patients had forceps delivery, one had a lateral placenta praevia, one required internal version, and one had Caesarean section. Since all were delivered in a hospital where only complicated or abnormal cases are accepted, this proportion of abnormal deliveries is not unusual. The fact that all the infants showed some degree of asphyxia at birth, and that in six of them asphyxia was severe, may or may not be significant.

The nerve lesion—The slough on the buttock did not always accompany the most severe nerve lesion. Thus of five infants developing a slough, one died, three failed to regain useful power, but one recovered completely. Of the six patients without skin slough, four regained no useful movement and two recovered fully. It seems evident that sufficient pressure may be exerted on the sciatic nerve to cause complete paralysis without producing a skin slough which, indeed, is characteristic of tourniquet paralysis and compression lesions of the musculospiral nerve such as crutch paralysis. In Case 7 in which the nerve lesion recovered completely, although there was a slough over the buttock, it is probable that the pressure responsible for ischaemia was not applied directly over the nerve.

No attempt has been made to calculate the time during which local pressure must be maintained to cause nerve paralysis, but two observations suggest that it must act for some time before the onset of labour. In Case 7, although there was a sciatic nerve lesion and sloughing of the skin of the buttock, the duration of labour was only five and a half hours—hardly long enough to cause such extensive damage. In Case 4 the affected foot was noticeably smaller than its fellow at birth, and it may well have been compressed in utero for several weeks.

Prognosis—The condition is serious. In three of ten survivors the paralysis recovered sufficiently for the limbs to be normal or almost normal; but in the other seven, despite many months of treatment, no useful movement was regained in muscles supplied by the lateral popliteal nerve. These seven patients, aged from nine months to three years, have a foot which is obviously small, with impaired sensation, and with shortening of not less than half an inch.

Treatment—In earlier cases the ankle was splinted at a right angle but, more recently, treatment has been limited to maintaining full passive movement by frequent manipulation. When a full range of movement is preserved the children walk surprisingly well. The oldest patient of this series, now three years of age, has a gait which is almost normal.

SUMMARY

1. It is possible that neonatal sciatic palsy occurs more often than is suggested by perusal of the literature: paralysis of a foot may easily be overlooked in the new-born infant; it may be regarded as a temporary paresis due to mild birth trauma; or in later months it may be attributed to poliomyelitis.
2. Eleven cases of neonatal sciatic palsy are reported. Autopsy in one suggested that the paralysis was due to direct pressure on the sciatic nerve before birth.
3. A hypothesis is advanced by which to explain how pressure on the nerve trunk may arise in utero.

The author thanks Mr St George Wilson and Mr P. B. Moroney for access to the records of the Obstetrical and Orthopaedic Departments of Walton Hospital.

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COMMENT BY BRYAN McFARLAND

Director of the Department of Orthopaedic Surgery, University of Liverpool

In 1948, Fahrni presented to the British Editorial Board of the Journal of Bone and Joint Surgery his article on "Congenital Sciatic Palsy." On reading it, my attention was arrested by the fact that during a single year, in one hospital where three thousand babies are born each year, Fahrni saw eleven cases of neonatal sciatic paralysis. I could not reconcile this very high incidence with the contrasting fact that during a period of twenty years before 1947, at children's hospitals with large out-patient attendances, I could not remember seeing one such case. On searching my records, four cases of neonatal sciatic paralysis were found to have attended my department in late 1947 and early 1948, but it was ascertained that all the mothers of these infants had been delivered at the same hospital where Fahrni saw his cases. We inquired at a maternity hospital with an annual birth rate of nearly 2,000 and learned that they had no recorded case of sciatic palsy over the last ten years. A similar answer was received from several other large maternity hospitals in Great Britain. I felt, therefore, that investigations as to the cause of the condition should be pursued before the article was published. Mr Fahrni, who was not wholly satisfied with the tentative explanation he had put forward, could not take part in this inquiry because he had already returned to Canada.

I first arranged examination of all the birth records in the hospital in which Fahrni's cases were seen. What was the procedure adopted in normal cases and in cases of asphyxia neonatorum? Asphyxia was the constant feature in all his cases of sciatic palsy and it seemed possible that some manner of handling the asphyxiated child might be responsible for the paralysis: for instance, if the same midwife had attended all eleven confinements there was a possibility that she had pinched or slapped the infant in some way peculiar to her. Austin O'Malley who conducted this part of the investigation found that the confinements were not all conducted by the same midwife. He noticed, however, that the routine treatment of neonatal asphyxia included the injection of a certain proprietary drug into the umbilical cord. In the other maternity hospitals where we had made inquiries, a different proprietary drug was so injected.

It may seem a far cry from the umbilical cord to the sciatic nerve but actually the connection is not so remote. The hypogastric artery, coming from the cord, runs into the

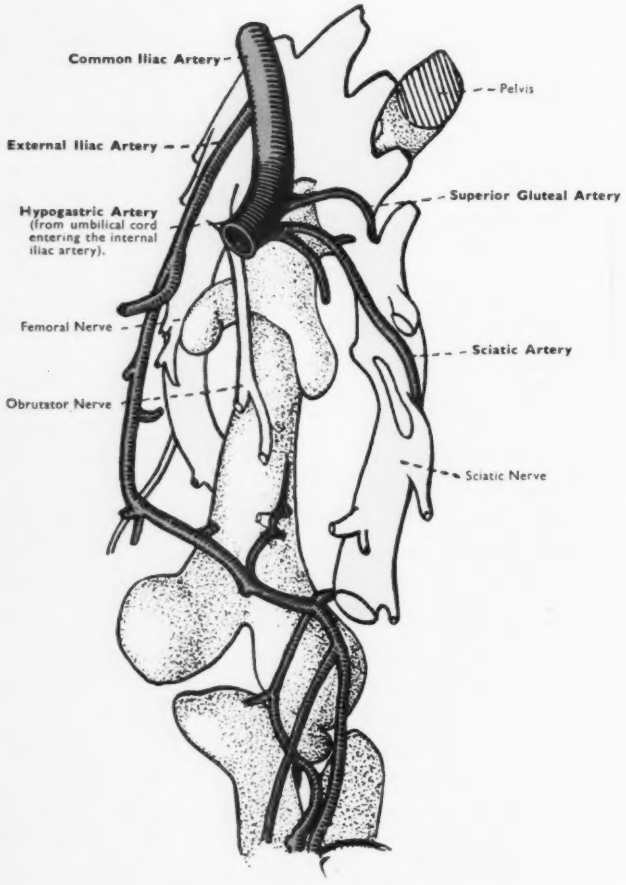

FIG. 5

Arteries of the right side of the pelvis and thigh in a human embryo of 18 millimetres (after H. D. Senior, New York).

internal iliac artery; and in the foetus this is a larger vessel than the external iliac artery. Below the entry of the hypogastric artery the next branch of any size to leave the internal iliac is the inferior gluteal artery (Fig. 5). If a few cubic centimetres of fluid entered the hypogastric artery it would soon reach the internal iliac, and if it proceeded along the main trunk of the internal iliac it would be scattered among the various branches and the amount of drug at any one point would be insufficent to cause appreciable damage; but if the fluid left the internal iliac by the first big branch it would be concentrated in the tissues immediately supplied by the inferior gluteal artery which includes part of the sciatic nerve, the muscles and the lower half of the skin in the gluteal region—in fact the very zone in which Fahrni found his lesion. This is a comparatively circumscribed zone, and concentration of any injurious drug would be sufficient to damage the tissues. Naturally not every case of

asphyxia neonatorum would develop sciatic palsy; it could occur only when the needle entered an umbilical artery; and even in these cases it could occur only when the fluid containing the drug actually entered the inferior gluteal artery and did not flow quickly past it.

The practice of injecting the particular drug which was suspected was abandoned while tests were carried out by the Department of Physiology and the Department of Pharmacology of the University of Liverpool. New-born kittens were injected; some developed a limp, but the lesion itself was not demonstrated. In another series the drug was injected subcutaneously, and in every case it produced a slough, thus proving that it was injurious to body tissues. It has been planned to inject at birth the umbilical cord of a monster; but this obviously would have to be a very special occasion and up to the present time the occasion has not arisen. Attempts have also been made to demonstrate the course of events in premature still-births but these have failed, not surprisingly, because the necessary flow of blood does not exist. The investigations are fully described by Hudson, McCandless and O'Malley in the *British Medical Journal*, January 28, 1950, page 223.

It would be fair to say that we have not yet complete proof that Fahrni's lesion of the sciatic nerve arises from the injection of noxious drugs into the umbilical cord; and that experimental findings, suggestive as they may be, are not yet conclusive; but there is clinical evidence which may be more important than experimental proof. So far as we can ascertain, the incidence of such paralysis was largely restricted to one hospital where eleven cases occurred within a year; and in the two years that have elapsed since the practice of injecting this particular drug into the umbilical cord has been suspended, no other case of neonatal sciatic palsy has been observed. If further proof is needed, we, in, Liverpool, would be very pleased to give every facility; but for my part I am satisfied.

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CONGENITAL TORTICOLLIS

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" As knots, by the conflux of meeting sap,
Infect the sound pine, and divert his grain
Tortive and errant from his course of growth."
(*Troilus and Cressida*. Act I, Scene 3)

The pathology of congenital torticollis has been the subject of investigation for more than a hundred years, ever since Stromeyer suggested that congenital sternomastoid tumour and congenital torticollis might be stages in one continuous process. The deformity is so obvious that it must have been known from the time that man first began to observe the traits of his fellows. Alexander the Great was claimed as the hero of torticollis (Colonna 1927, Little 1928), the evidence being in Plutarch's " Lives " where the writer noted " Alexander's manner of holding his neck hanging down towards the left side." But Alexander was renowned for his physical beauty, and the few authentic portraits and busts that are available show no facial deformity (Fig. 1). Moreover it should be remembered that slight lateral inclination of the head has often been favoured by distinguished persons, and that in the representation of mediaeval saints " torticollis " has played no less a role than the halo over their heads.

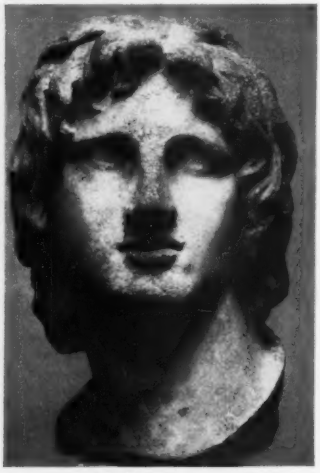

FIG. 1

Bust of Alexander the Great. The alleged wry-neck is shown, but no facial asymmetry. This is not a deformity: it is a pose. (Reproduction by courtesy of the British Museum.)

Antyllus is said to have practised tenotomy for torticollis in the second century but it was only the writings of Oribasius, one century later, that preserved our knowledge of him. Fabricius of Padua, the tutor of William Harvey, devised a brace for correction of the deformity but his results were not recorded. In 1641 a German doctor, Isaac Minnius, made the first known attempt at surgical correction (Hough 1934, Little 1928); and in 1670 the operation was again described by Rouenhuysen in Holland. In mediaeval times, subcutaneous tenotomy was performed by itinerant practitioners in the fairs of England to the accompaniment of clanging cymbals by which to drown the cries of their victims (Power 1933). The Vicar of Stratford-on-Avon, the Reverend John Ward (1663–1681) described the insertion of a lancet beneath the muscle, cutting from within outwards. It appears that these practitioners never injured the underlying veins, which, if true, is a humiliating thought when we recall how often the subcutaneous operation is now condemned because of the danger to great vessels. In 1749 William Cheselden of St Thomas's Hospital published a treatise, " Observations on Le Dan's Operations of Surgery " in which is described and illustrated the operation of open tenotomy of the sternomastoid (Fig. 2). He asserted that after division of the sternal

attachment the clavicular head of the muscle could be stretched. Dupuytren performed subcutaneous tenotomy on one of his servants in 1828, and demonstrated his technique to Symes who later introduced the operation to Edinburgh.

PATHOLOGY

The records of one hundred patients with congenital torticollis seen between 1938 and 1945 at the Hospital for Sick Children, Great Ormond Street, have been studied. Congenital skeletal abnormalities were excluded. The cases fell into two groups according to the age at which the deformity became obvious.

Group A comprised sixty-seven children with torticollis noticed at or soon after birth who were brought to hospital between the ages of three weeks and three months, the average age being six weeks; in no case was operation needed. In Group B there were thirty-three patients with torticollis first noticed long after birth who were brought to hospital between the ages of one and ten years, usually at about the age of four years; and in twenty of these patients operation was necessary. Evidence will be presented to show that there is an essential difference in the pathology and treatment of these two groups. In Group A the condition is postural and temporary; in Group B there is a true congenital deformity associated with pathological changes in the sternomastoid muscle.

FIG. 2

Division of the sternal head of the sternomastoid muscle for wry-neck, from Cheselden's Observations on Le Dan's Operations of Surgery, 1749.

Stromeyer said that injury to the foetal neck at birth caused a haematoma of the sternomastoid muscle which then contracted (Hough 1934). His contribution was supported only by the evidence of four cases but it was important because it correlated the sternomastoid tumour with torticollis and emphasized the significance of the obstetric history. The relationship between sternomastoid tumour and torticollis has been debated ever since. Four sternomastoid tumours were recorded in eighteen cases of torticollis by Clutton (1888), twenty tumours in 106 cases by Power (1893), and twenty-three tumours in one hundred cases by Gray (1935). In this series of one hundred patients a sternomastoid tumour was recorded in fourteen. Middleton (1930) reported experimental evidence in favour of the pathological continuity of the two diseases and showed that the " tumour " consisted of interstitial fibrosis which went on to fibrous contracture; but he was unable to explain why in four cases out of five the tumour appeared to resolve and leave a normal muscle.

The causation of torticollis—It seems probable that there is a relationship between sternomastoid tumour and congenital torticollis and nearly all hypotheses are based on this assumption. At least six are worthy of consideration.

1) *The hypothesis of birth injury* was formulated by Stromeyer and presented fully by Witzel (1891) who believed that there might be abnormal intra-uterine development of the sternomastoid producing a shortened muscle which was torn at birth with the formation of a haematoma which underwent fibrous contracture. There is no doubt that sternomastoid

TABLE I

CLASSIFICATION OF CONGENITAL TORTICOLLIS

	Group A	Group B
Number of cases . . .	67	33
Average age	6 weeks	4 years
Number requiring operation	Nil	20

TABLE II

REPORTED INCIDENCE OF STERNOMASTOID TUMOUR IN CONGENITAL TORTICOLLIS

Author	Year	Total cases	Sternomastoid tumour	
			Cases	Percentage
Clutton . .	1888	18	4	22
Power . .	1894	106	21	20
Gray . .	1934	100	23	23
Hospital for Sick Children	1947	100	14	14

tumours occur with frequency after difficult labour; and in this series there was a history of difficult labour in more than half the patients. But the evidence against this interpretation is overwhelming. The tumour is hard and discrete, and there is no discolouration of the skin such as might occur after a haematoma. Moreover, ruptured muscles elongate; they do not contract. There is no haemosiderin in the tissues in old cases. Even early cases, examined within a few weeks, show a mass of glistening white fibrous tissue with no evidence at all of blood. The tumour is certainly not caused by a haematoma.

2) *The ischaemic hypothesis*, first suggested by Mikulicz, was brought into prominence by Nové-Josserand and Viannay (1906) who compared the muscular fibrosis of torticollis with that of Volkmann's contracture. They showed that the blood supply of the sternomastoid was precarious. The sternal head and middle fibres of the muscle are supplied by the sternomastoid branch of the superior thyroid artery which has been proved to be an end-artery. The circulation of this part of the muscle may be obstructed by placing the head in certain positions. Necropsies of twenty newly born infants showed that lateral flexion of the head with elongation and torsion of the neck prevented material injected into the carotid artery from reaching the muscle. The results of such experiments in the cadaver should not of course be applied without reserve to the arterial circulation of the living; and it is to be noted that those who have excised the sternomastoid tumour have noted the vascularity of the tissues. Moreover, Brooks (1922) pointed out that ligation of an artery does not cause atrophy and massive fibrosis.

Middleton (1930) postulated that venous occlusion produced ischaemia in muscle. He believed that venous drainage of the sternomastoid was separated into three fields—the mastoid, clavicular and sternal parts. The clavicular and sternal veins might be obstructed by torsion of the foetal head in the second stage of labour, thus producing ischaemia of the muscle. This view has been criticised by recent observers who claim that the muscle is drained by a common venous bed which cannot be obstructed so easily (Chandler and Altenberg 1944). Middleton went further and suggested that birth injury caused venous

thrombosis in the muscle; but this again has not been confirmed by later investigations (Chandler and Altenberg 1944).

The supposition that torticollis might be due to ischaemic necrosis is open to even more serious criticism. The susceptibility of various tissues to ischaemia differs greatly. Nerve cells are damaged irreparably by deprivation of their blood supply for a quarter of an hour, and muscle dies after six or seven hours (Watson-Jones 1946).is If chaemic necrosis is produced in the sternomastoid muscle by stretching or torsion of the head during the second stage of labour it must necessarily be presumed that the foetal head has been retained in this position for several hours with consequent interference with the cerebral circulation. In these circumstances the breech delivery that is characteristic of most patients with this condition must surely have proved fatal. It might be argued that birth injury produced arterial spasm

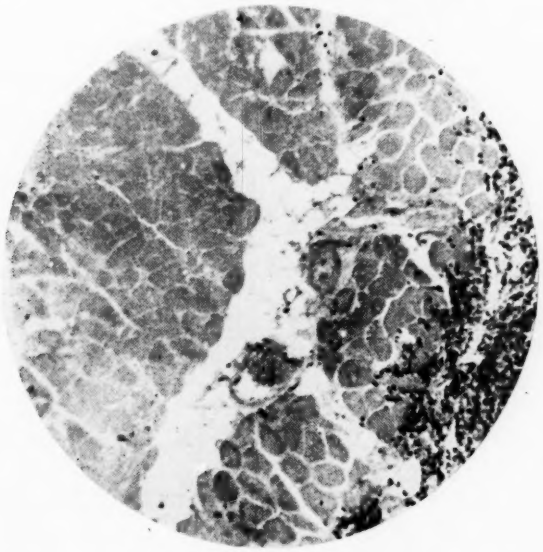

FIG. 3

The histological appearances of ischaemic necrosis. There is a massive necrosis of muscle tissue, with a peripheral cellular reaction. (Reproduced by permission of Mr D. Ll. Griffiths and the British Journal of Surgery.)

but this is ruled out on histological grounds. Griffiths (1940) showed that the histological appearances of ischaemic muscles in Volkmann's contracture of the forearm differed from those of the sternomastoid tumour, and from the experimental lesions produced by Middleton. The histological appearance in Volkmann's ischaemia is that of a muscle sequestrum: the general contour is preserved but the tissue is dead, with no living nuclei in the muscle fibres; the necrotic area is surrounded by a zone of phagocytic activity and eventually there is replacement by fibrous tissue which invades the slough from the periphery inwards (Fig. 3). In contradistinction, the sternomastoid tumour contains islands of muscle tissue surrounded by masses of cellular fibrous tissue and the characteristic muscle slough of Volkmann's ischaemia is not seen (Fig. 4).

The fact that the sternomastoid tumour which appears towards the end of the second week of extra-uterine life contains cellular fibrous tissue should be noted. It seems unlikely that a pathological process occurring at the time of birth could produce mature fibrous

tissue within two weeks, and this observation casts doubt upon any theory that is based on causative factors operating at the time of birth.

3) *The hypothesis of intra-uterine malposition*—The conception that congenital deformity is the consequence of abnormal intra-uterine position dates from the time of Hippocrates and has long been considered a possible explanation of torticollis (Browne 1936). In 1944 Chandler and Altenberg described a case in which ante-partum radiographs showed breech presentation with the foetal head in right lateral flexion. The baby was delivered by Caesarian section; and right-sided torticollis which was present at birth became increasingly pronounced. A sternomastoid tumour was noticed after fourteen days and it was excised. Rossi (1928) reported a similar case of torticollis found at Caesarian section in which the tumour was present at birth. Joachimstal and Volcher (1904) described torticollis in an extra-uterine pregnancy. These reports suggest that torticollis is present at or before birth and that the sternomastoid tumour may be the result rather than the cause of the torticollis.

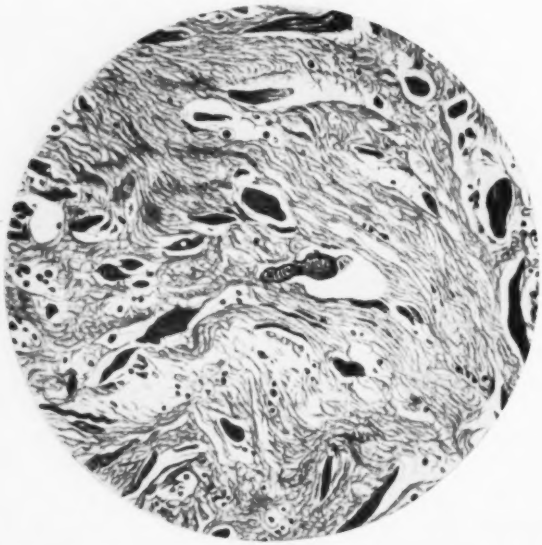

FIG. 4

The histological appearances of the sternomastoid tumour. Note the islands of muscle tissue in a mass of cellular fibrous stroma. Compare with Figure 3. (After Middleton, by permission of the British Journal of Surgery.)

The high incidence of obstetric abnormalities, especially breech presentation, has been explained in various ways. Sippel (quoted by Chandler and Altenberg 1944) suggested that inability of the wry-necked foetus to engage normally in the pelvis caused breech presentation. Browne (1936) pointed out that postural torticollis was associated with flattening of the opposite side of the head, as if it had been moulded by the uterine wall; and he described a number of infants with moulding of the lobe of the ear which suggested pressure against the shoulder while the head was flexed to that side. One case with such moulding also showed facial paralysis from compression of the facial nerve. Of sixty-seven cases of postural torticollis in the series now reported, four showed the triad of torticollis, crumpled ear and facial paralysis. The frequency with which these signs are associated is enough to justify the assumption that they may have a common cause. Moulding

of the head was seen in nearly all children with postural torticollis, and in these cases the clinical evidence in favour of intra-uterine malposition seems to be convincing. Nevertheless postural torticollis was never associated with a tumour and never gave rise to structural contracture. It seems clear therefore that some other factor must be responsible for the muscular type of torticollis with sternomastoid tumour.

4) *The hereditary hypothesis* which was advanced in the last century has never found favour (Tubby 1912). In this series there was only one example of the deformity occurring in mother and child. No series published in the literature has shown any higher incidence.

5) *The hypothesis of infective myositis*—Since the sternomastoid tumour is characterised by interstitial fibrosis it has been suggested, though unconvincingly, that it is the end-result of an infective myositis. MacLennan (1943) described the appearances of infective myositis; they are quite different from those of the sternomastoid tumour. Moreover no infective agent, and no evidence of syphilis, has ever been discovered.

6) *The nervous hypothesis*—Atrophy of the anterior horn cells has been reported in an adult case of torticollis but this is comparable to the similar atrophy that occurs after amputation of a limb and there is no evidence whatever that it is a significant factor in causation.

Summary of hypotheses—The *postural* type of torticollis can be attributed to intra-uterine malposition on the evidence of associated moulding of the head with occasional deformity of the ear and facial palsy. The *muscular* type of torticollis with its associated sternomastoid tumour is usually attributed to ischaemic necrosis. That this view should be reconsidered is quite clear from the evidence here presented. The histology of sternomastoid tumours is not that of any known type of ischaemic necrosis. Interstitial fibrosis of this type cannot be produced experimentally; and it has been shown that the tumour cannot be produced at birth. It must be acknowledged that the real cause of this peculiar fibrous tumour remains unknown.

CLINICAL FINDINGS

The accepted clinical picture of congenital torticollis—About ten days after birth a tumour appears in the substance of the sternomastoid which may or may not be associated with transient spasmodic torticollis lasting a few days or weeks. The tumour occupies most of the muscle but is circumscribed. Both heads of the muscle are usually involved but sometimes the swelling is confined to one head. It persists for two or three months and then disappears gradually in from four to six months. The development of torticollis is delayed until the age of three or four years when the short neck of the infant lengthens into that of the young child. As growth proceeds the torticollis leads to facial asymmetry which becomes permanent if the deformity is allowed to persist. The mastoid process on the affected side becomes elongated and ossification may occur in the clavicular origin of the muscle. In neglected cases there is cervical scoliosis and sometimes contraction of the field of vision.

Clinical features in this series of cases—*Onset of the tumour*—The tumour was usually noted within the first month of life, and four were seen within the first few days. Sternomastoid tumours have been seen at birth by Rossi (1928) and Chandler and Altenberg (1944).

Clinical nature of the tumour—Our cases corresponded closely with the classical description. The fibrous process involved nearly the whole sternomastoid muscle but was confined to it. The patient was a male in 54 per cent. of cases; and the lesion was on the right side in 52 per cent.

Disappearance of the tumour—The tumour usually disappeared by about the seventh month. The earliest disappearance was at two months and the latest at eleven months.

Onset of torticollis—In Group A cases the postural deformity was present at birth, was transient, and left no structural deformity. In Group B cases the deformity was sometimes, though not always, associated with a history of antecedent sternomastoid tumour. Several patients were first brought for advice at the age of six or seven years, and in one the deformity was not noticed until the age of eight years. On the other hand deformity was noticed in one patient

soon after birth, in two at four weeks, and in one at six weeks. These findings are in general agreement with those of Middleton (1930) who found that the deformity seldom became obvious until the neck began to lengthen at about the age of three years.

Facial asymmetry was observed at an earlier age than is usually described. Asymmetry of slight degree can be detected by examination of the head and neck from behind—the " scoliosis capitis " of Middleton. In the same way that dorsal scoliosis with vertebral rotation causes flattening on one side of the chest and bulging on the other, rotation of the cervico-cranial vertebrae gives rise to asymmetry of the skull. This may even be present in new-born babies when it is probably due to intra-uterine torsion. Facial asymmetry may of course complicate any longstanding cervical deformity whether from dislocation, tuberculosis disease or scar contracture. Walter (quoted by Hough 1934) produced reversal of the facial asymmetry by over-correction maintained for seventeen weeks; and Tubby (1912) believed that facial asymmetry always disappeared within three years of operation.

The obstetric history—In our series of patients with sternomastoid tumour the incidence of obstetric complications was: breech delivery, 40 per cent.; forceps delivery, 20 per cent.; difficult labour, 9 per cent.; total incidence, 69 per cent. These figures are compared with those of other authors in Table III.

TABLE III

REPORTED INCIDENCE OF OBSTETRIC COMPLICATIONS

	Breech	Forceps	Difficult labour	Total
	per cent.	per cent.	per cent.	per cent.
Witzel (1891)	44	19	9	72
Middleton (1930)	—	—	—	72
Chandler and Altenberg (1944) .	30	23	8	61
Hospital for Sick Children (1947)	40	20	9	69

Breech presentation occurs in about 3 per cent. of all pregnancies, and the greater incidence in cases of sternomastoid tumour is significant. Breech delivery seldom causes injury and it seems probable that it is the position in utero, rather than the nature of delivery, that is the factor of etiological importance. This relationship was stressed by Chandler and Altenberg who quoted the radiographic evidence of Isigkeit and Sippel. The high incidence of difficult delivery has long been considered significant in the causation of the tumour but doubt is cast upon this view by the occurrence of the condition in babies delivered by Caesarian section.

TREATMENT

Non-operative measures—Most patients with sternomastoid tumour, and all with postural torticollis, were treated successfully by early manipulation by the physiotherapist and the mother. There has been some misunderstanding as to the method of manipulation. The combined action of both sternomastoid muscles is to extend the head on the neck and draw forward the cervical spine. The insertion of the muscle into the mastoid process is behind the occipital condyles, so that it is an extensor of the atlanto-occipital joint (double torticollis, which is very rare, is characterised by extension of the head and flexion of the neck—the " sniffing the air " position). The neck should of course be flexed laterally to the opposite side, and the head rotated to the same side (Fig. 5); but flexion of the neck is obviously a fundamental part of the manipulative treatment (Fig. 6). Lorenz advocated subcutaneous rupture, or myorrhexis, after the manner of his treatment of the contracted adductors in congenital dislocation of the hip; but Reiner (1896) and Brackett (1897) recorded sudden and dangerous collapse during this procedure.

Operative treatment—*Subcutaneous tenotomy* is condemned by most writers but defended vigorously by others (Elmslie 1943). It is practised to-day by many surgeons of repute. The operation is said to endanger the great vessels, particularly the external jugular and anterior jugular veins, and the communicating channel between them. A further objection is that division of the contracted tissues may be incomplete. The operation for torticollis is largely cosmetic and the subcutaneous operation has the advantage that it produces no scar. Injury to the vessels can be prevented by performing the tenotomy low down and cutting on to the clavicle, and if the operation is performed through a quarter-inch incision the risk to the vessels is further reduced. This is a good method which should be practised more widely.

Open tenotomy—The results of open tenotomy in twelve patients, examined fifteen to twenty years afterwards, were cosmetically imperfect. The scar was usually placed horizontally just above the clavicle. It tended to stretch and become unsightly, and there was sometimes keloid formation. Complete division of both heads of the muscle is usually all that is necessary,

FIG. 5

FIG. 6

In the manipulative treatment of torticollis the neck must of course be flexed away from the affected side and the head rotated towards it (Fig. 5); but forward flexion of the neck is fundamental (Fig. 6).

but sometimes the cervical fascia, omohyoid and scalenus anterior may have to be divided. This procedure is criticised by many because the pathology is confined primarily to the sternomastoid muscle. Tubby (1912) used an oblique incision along the lower part of the anterior edge of the sternomastoid and reported good cosmetic results in a few cases. But it is now recognised that almost any incision in the neck is unsightly and even a collar incision if placed too low may leave an ugly scar.

Division of the upper end of the sternomastoid was introduced by Tillaux and Lange. It is said that if the muscle is allowed to slide too far—more than about one inch—traction on the spinal accessory nerve may cause paralysis. Apart from this possible complication, detachment of the occipital and mastoid insertions of the muscle through an incision within the hair line gives good correction and a satisfactory cosmetic result. Hellstadius (1927) practised the combined operation of open division of the upper end and subcutaneous division of the lower end, and Denis Browne has employed a similar operation for many years.

Z-shaped lengthening of the muscle—Jones and Lovett (1929) described a method of lengthening the muscle by an oblique or Z-shaped incision. Another method is that of elongation of the sternal head with restoration of continuity of the tendon (Elmslie 1943).

Resection of the muscle—Resection of the sternomastoid was first advocated by Mikulicz. Recently Chandler and Altenberg (1944) advised removal of the sternomastoid tumour during the first few weeks of life. The operation cannot be recommended because four out of every five tumours resolve completely and leave no deformity; and moreover when torticollis does develop it can be corrected by a much simpler procedure at about the age of three or four years.

Post-operative treatment—There are many ways of maintaining correction after operation (Fig. 7). Mediaeval practitioners used a cap which was fastened by fillets beneath the axilla (Power 1893). Plaster caps with similar bands are used to this day at the Hospital for Sick Children in London. Others rely on physiotherapy started as early as possible and pursued conscientiously over a prolonged period. Treatment should be continued for at least six months and every patient should be kept under observation for several years.

FIG. 7

Trethowan's collar used in the after-treatment of torticollis. It is not so much a splint as an active reminder that the head and neck must be held away from the flange.

SUMMARY AND CONCLUSIONS

1. One hundred cases of torticollis and 117 cases of sternomastoid tumour have been reviewed.

2. Congenital torticollis can be sub-divided into two groups: postural and muscular.

3. Congenital postural torticollis is present at birth; it is not associated with a sternomastoid tumour; it is transient in nature; and it does not require operation for its relief.

4. Congenital muscular torticollis is preceded by a sternomastoid tumour which is clinically evident in one-fifth of all cases.

5. The ischaemic theory of the causation of sternomastoid tumours is not supported by recent histological investigations. Some other cause, which probably is operative before birth, must be sought.

6. Four-fifths of all cases of sternomastoid tumours resolve spontaneously and leave no deformity. Excision of the tumour in infancy is therefore unjustifiable.

7. Open division of the muscle and of the cervical fascia in congenital muscular torticollis cures the deformity but leaves an unsightly scar.

8. Subcutaneous tenotomy can be relied upon to cure the deformity if post-operative treatment is carried out skilfully and assiduously over a prolonged period.

9. If complete correction is not gained at the time of subcutaneous tenotomy a better result can be assured by open division of the upper end of the muscle through an incision within the hair line.

I wish to express my thanks to the surgical staff of the Hospital for Sick Children, and especially to Mr Eric Lloyd and Mr Denis Browne, and to the Department of Clinical Photography at the West Hill Hospital, Dartford.

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THE USE OF POLYETHYLENE AND RESINATED ASBESTOS FELT FOR SPLINTS

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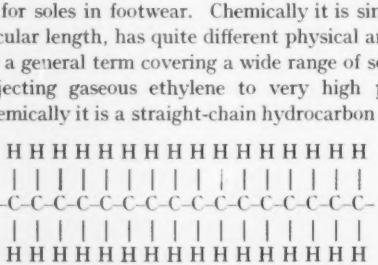
Since our last report (1948) two new materials, polyethylene and resinated asbestos laminate, have been introduced for the manufacture of splints. In this paper, preparation and working methods are described. The illustrations show stages in making a cervical collar and a hip spica. It will be clear that polyethylene* and resinated asbestos felt† which have certain advantages over celluloid and moulded leather, should be regarded not as substitutes but as useful additions to a range of synthetic materials which permit the degrees of rigidity and flexibility required for various appliances.

POLYETHYLENE

Polyethylene was first introduced just before the recent war and is now used widely as an electrical insulant and for soles in footwear. Chemically it is similar to paraffin wax but because of its great molecular length, has quite different physical and mechanical properties. The name polyethylene is a general term covering a wide range of solid polymers of ethylene (C_2H_4) prepared by subjecting gaseous ethylene to very high pressure under carefully controlled conditions. Chemically it is a straight-chain hydrocarbon of the form shown below:



The individual molecules may contain as many as a thousand carbon atoms. It is a typical thermoplastic, melting at about 119 degrees centigrade to become a viscous liquid. In the softened state it can be extruded and moulded by compression or injection. At room temperatures it is tough and flexible, and remains so, well below 0 degrees centigrade. Though waxy in appearance, it is translucent in the range extending from the longest infra-red waves to about 2200 Angström units in the ultra-violet field. There are slight general absorption bands in the ultra-violet range but no sharp lines. This wide-range translucency is advantageous clinically because the splints need not be removed for treatment by ultra-violet light or sunlight. Prolonged ultra-violet irradiation may cause a slight yellow discolouration, but this is of no significance.

Polyethylene, with a specific gravity of 0·93, is one of the lightest thermoplastics yet produced (compare methyl-methacrylate, trade name "Perspex," specific gravity 1·19). It is almost insoluble in all organic liquids at room temperature. At higher temperatures it is soluble in a number of hydrocarbons and chlorinated hydrocarbons such as benzine, xylene, toluene, tetralin, petroleum ether, medicinal paraffin, lubricating oils, turpentine, trichlorethylene, carbon tetrachloride and chlorobenzine.

* Made by Imperial Chemical Industries, Ltd., under the trade name "Alkathene," in thicknesses from $\frac{1}{16}$ in. to $\frac{1}{2}$ in.

† Made by Turner Brothers Asbestos Co., Ltd., Rochdale, under the trade name "Durestos," in three standard grades, RA1, RA2 and RA3, each in three thicknesses.

After being worn for a few months, splints made from polyethylene tend to become a little yellow. This is thought to be due to slow oxidation—which does not, however, affect the strength or durability.

Manipulation of sheet polyethylene—Some points in the preparation of the positive and negative casts should be noted. 1) The plaster should extend two or three inches beyond the proposed margin of the splint, so that a good edge can be obtained by cutting back the material to the required size. 2) The positive should have a central core-space to permit economy in the use of plaster, ease of handling, suspension while in the oven and quicker drying. 3) The positive should be covered with a suitable "release" material so that the plastic does not bond itself to the plaster.

FIG. 1

Sheet polyethylene with reinforcement strip on asbestos board, covered with French chalk and ready for heating.

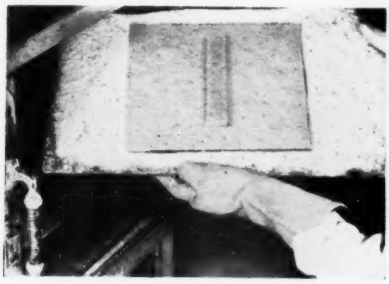


FIG. 2

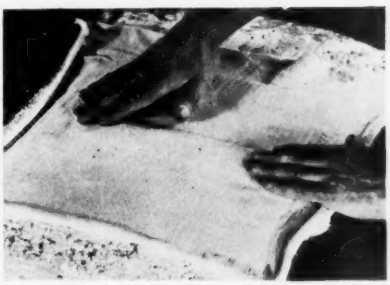


FIG. 3

After heating the sheet is transparent and viscous. It is ready for moulding over a plaster cast (Fig. 2). Stockinet is applied to the softened polyethylene as a "carrier" (Fig. 3).

Polyethylene is most suitable for splints in which some resiliency is allowed. Uncoloured sheets in thicknesses from $\frac{1}{16}$ inch to $\frac{3}{16}$ inch are used in orthopaedic work; greater thicknesses are not required. They should be free from anti-oxidant (polyisobutylene) which might cause dermatitis. The measurements of the positive plaster casts are taken and a margin of about one inch is allowed all round. A piece of polyethylene of the appropriate size is cut with an electric saw or, less easily, with a sharp leather-knife. If no reinforcement of the sheet is required it is placed on a perforated sheet of asbestos cement covered with French chalk to prevent adhesion of the material when it becomes soft (Fig. 1). The upper surface of the polyethylene is also covered with chalk. When reinforcement is required a strip $\frac{3}{16}$ inch thick is placed

appropriately on the larger sheet before dusting with chalk. If the contact surfaces are absolutely clean, the two sheets fuse perfectly at melting heat.

With their covering of chalk, the sheets are heated for ten to fifteen minutes in a gas or electric oven controlled by a thermostat at 120 degrees centigrade till the opaque sheet becomes transparent (Fig. 2); over-heating will cause bubbles to form and prevent successful manipulation. Meanwhile the positive casts, held in a vice by means of a metal rod incorporated in the plaster, are also covered with French chalk to give a non-adhesive surface. When the polyethylene has been heated sufficiently a piece of stockinet, which will act as a " carrier," is gently pressed on so that the threads become embedded (Fig. 3). Woven glass-fibre can also be used as a carrier but, although it gives a better surface to the finished splint, the added expense is usually not justified. If a carrier is not used it is impossible to get a consistent thickness, as the hot polyethylene runs like treacle.

FIG. 4

The polyethylene and carrier are moulded over the plaster cast.

FIG. 5

A typical cervical collar made from polyethylene for an adult patient.

The material can then be applied to the cast (Fig. 4). One edge of the stockinet and polyethylene is tacked to the cast and the remainder is stretched gently into position. The operator, wearing asbestos gloves if desired, maintains the splint in close contact with the cast for ten to fifteen minutes while the material is cooling. The remaining edges of the splint are tacked into position and left to cool on the cast for half an hour before removal. (At this stage instantaneous cooling by immersion in water is permissible but may spoil the plaster cast.) The inner surface crinkles slightly and allows air to circulate beneath the appliance; a few $\frac{1}{8}$ inch air-holes may be drilled to assist ventilation. On the outer surface the impression of the stockinet is more pleasant to the touch than a wax-like plain surface. The rough splint is fitted to the patient, trimmed with a knife, or sawn and smoothed off at the edges. Buckles and straps, or zip-fasteners, are riveted in position; and tongues are fitted where the splint edges come together, to prevent nipping of the skin (Fig. 5). At body temperature the splint has slight resilience but is not readily deformed. It may be kept clean either with soap and water or with a detergent such as cetyl-trimethyl-ammonium bromide.

RESINATED ASBESTOS FELT

Phenol-formaldehyde is a resin produced by the inter-action of phenol and formaldehyde in suitable proportions in the presence of a condensation catalyst such as sodium hydroxide. The resin as first prepared has the property of being converted by heat into an insoluble

solid, and is sprayed over asbestos fibres to form a "tacky" felt. Material in this raw condition is ready for the first stage in the manufacture of splints and appliances. In the process of preparation the asbestos fibres come to lie in the same direction; the material can therefore be stretched with the grain of the fibre but tears if pulled across the grain.

Phenol-formaldehyde resin has little intrinsic strength, and the strength of articles manufactured from it depends upon the use of a suitable "filler," in this case asbestos fibre. It is a thermo-setting plastic and is used in industry as a low-pressure (*i.e.*, less than 100 lb/sq. in.) laminating material. In the manufacture of splints and appliances, sufficient

FIG. 6

FIG. 7

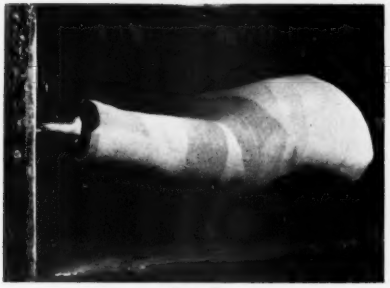


FIG. 8

FIG. 9

Tailored sheets of resinated asbestos felt prepared for a hip spica. The sheets are moistened with water before moulding over the cast (Figs. 6 and 7). The edges are teased to make a good joint. The cast and splint are bound with woven cotton bandage and suspended in an oven for curing (Fig. 8). Two halves of the cured spica after trimming are shown in Figure 9.

pressure is exerted by the drying-out of woven linen or cotton bandage, or of water-wettable cellophane, applied to the outside of the cast. Tests on pieces of cured felt, which had been moulded under pressure obtained with such simple methods, showed the following average results:

Tensile strength: 5220 lb/sq. in.
Shear strength: 3620 lb/sq. in.
Cross-breaking tensile strength: 4000 lb/sq. in.
Compression strength: 45,000 lb/sq. in.
The specific gravity is 0·81.

The uncured material contains phenol and formalin and may cause skin irritation in

susceptible persons concerned with handling or manipulation; this trouble can be avoided by using a barrier cream. The cured material of the finished splint is non-irritant.

Manipulation—The thin and medium thickness sheets are the most useful for moulding. Resin content and type of fibre vary with the specification: grade RA2 gives the best results in orthopaedic work. A spica is used here to illustrate the method of manipulation. The pieces are tailored in the manner shown in Figure 6. Two sheets are cut so that they can be applied right round the cast, and three to reinforce the back and the front. Off-cuts are used to strengthen the upper thigh, groin and buttock areas, where the greatest strain occurs. The felts are well damped with water to allow satisfactory moulding and bonding. The first large sheet is applied round the cast and the edges teased out to ensure a good joint on the lateral side. The smaller sheets are applied, one to the front and two to the back;

FIG. 10

FIG. 11

FIG. 12

The finished spica, weighing 2 lb. 4 oz. (Fig. 10). A dwarf with bilateral tuber-bearing laminated felt pylons, weighing 1 lb. 15 oz. and 2 lb. 4 oz. respectively (Fig. 11). A light tuber-bearing laminated felt pylon for an above-knee amputation, used by the patient alternately with his standard prosthesis which weighed 5lb. 10 oz. without a shoe. A similar " Perspex " pylon weighed 5 lb. 8 oz. The appliance illustrated weighed 2 lb. and indeed it was so light that it was necessary to weight it with 20 ounces of lead at the lower end to give a good swing (Fig. 12).

and the whole is covered by the final large sheet. The grain of each succeeding layer should be laid at right angles to that of the preceding layer. (The direction of the grain is found easily on pulling the edge of the sheet.) All edges are well teased and smoothed into the layer beneath (Fig. 7). A smooth rubber roller may be used to ensure that all layers are well bonded. If time permits, the cast is allowed to dry for a few hours before the application of the bandage or cellophane. If a cellulose acetate solution is painted over the partly dry bandages, the evaporation of the solvent leaves a skin which contracts and gives a cast of superior strength and quality (Fig. 8). The splint is " cured " by heating. It is placed in a gas oven with the thermostat set at 75 degrees centigrade and allowed to cure for eight hours. At higher temperatures delamination is caused by the formation of steam. When cured, the spica is cut from the cast with a circular saw and, after fitting to the patient, finally trimmed. If ventilation holes are required they are drilled at this stage, before finishing. The inner surface is coated with a water emulsion of polyvinyl acetate, which on heating

for a few minutes in an oven forms a protective skin. The outer surface is coated with aluminium paint and finished with flesh-coloured cellulose lacquer. Straps and buckles or zip-fasteners are applied on one side and lacings on the other (Fig. 10). Splints may be cleaned with soap and water.

Excluding curing, production time is approximately one quarter of that required for cellulose acetate or moulded leather splints, which have to be reinforced with steel; the cost is about one half. The further advantages of the material are that it is durable and light, does not distort with use, is washable, unaffected by sweat, urine and faeces; and is non-inflammable. It is most suitable for rigid splints such as pylons, spinal jackets, spicas and long-leg gutters.

Footnote 1—In the preparation of splints from sheet polyethylene, instead of the usual white finish it is possible to make a flesh-coloured splint by using pink "Crinothene," one-thousandth of an inch (the trade name of the thin type of polyethylene produced by Imperial Chemical Industries) which is placed on top of the polythene with or without reinforcing strips before the application of chalk. The two sheets are heated together and, when they become clear, fusion will occur.

Footnote 2—A recent improvement in the "Durestos" technique has been released for publication by the Ministry of Supply and described by L. N. Phillips of the Royal Aeronautical Establishment at Farnborough (British Plastics, October 1949, 535). It was thought that if: 1) the adhesion between the felt could be improved; 2) some means of internal constraint could be used to reduce spring-back of the felts during curing; 3) the phenolic resin could be induced to catalize at lower temperatures, a much stronger laminate would be secured. These objects have been achieved by using a resorcinol formaldehyde glue modified with furfuryl alcohol. "Aerolite 185," a commercial resorcinol formaldehyde glue is activated for use by the addition of one-fifth by weight of paraformaldehyde; furfuryl alcohol, 1 to 2 per cent., is added after compounding, and this aids in the dispersion of the glue through the felt. This glue reacts with the phenol resin present in the felts and enables them to be cured at lower temperatures than normal. The glue is spread on the felt during the laminating process by brushing, and about twenty-five square feet of felt per pound of resin can be so treated. The strength figures of the cured laminate are considerably increased and for some appliances this has been found to be an advantage.

I wish to thank Mr H. J. Seddon and other members of the staff of the Royal National Orthopaedic Hospital for their help and constructive criticism. Much credit is due to my technical assistant, Mr T. Fisher, for his ingenuity in perfecting the technical methods. I also wish to thank Mr G. May of Dufay-Chromex Ltd., and Mr S. Holt of I.C.I. (Plastics Division) Ltd., for their advice and for the supply of materials during the early stages of this work; Mr M. Howe of Turner Brothers Asbestos Co. Ltd., Rochdale, who arranged for strength tests on "Durestos"; Dr W. Bodger of Revertex Ltd., for various polyvinyl acetate emulsions; British Cellophane Ltd., for supply of material; and Mr T .Whitly for the photographs.

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OBLITERATION OF THE NAIL BED OF THE GREAT TOE WITHOUT SHORTENING THE TERMINAL PHALANX

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From the Wharncliffe Hospital, Sheffield

Ingrowing toe nail and onychogryphosis arising from deformity of the nail bed of the great toe often give rise to much disability, and although many treatments have been used none is entirely satisfactory. Conservative measures such as thinning the nail and cutting a longitudinal groove may control the ingrowing, and repeated filing may suffice for onychogryphosis, but such treatment must be continued indefinitely. Repeated avulsion seldom gives permanent cure, and excision of a wedge from the lateral border causes persistent deformity of the nail. Removal of the whole nail bed together with excision of the distal half of the terminal phalanx is often satisfactory but the cosmetic result is poor; the wife of one of my friends who was so treated described her great toes as " two funny little dumplings." Complete excision of the nail bed with mobilisation and suture of the proximal and distal flaps (Nuttall 1941) failed in three cases because tension caused necrosis of the flaps so that the wounds broke down. Moreover excision of the nail bed with skin grafting of the raw area is uncertain.

Excision of all the nail bed is not necessary. Growth of the nail, both in length and thickness, takes place only from the proximal part of the nail bed. The nail bed distal to the lunula makes no contribution and, if growth of the nail over it is prevented, it will assume the characteristics of normal skin (Hermitte 1947). The operation described here is based upon these observations. The purpose is to remove the nail-forming part of the nail bed and provide adequate skin cover without shortening the distal phalanx.

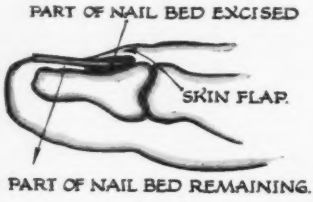

FIG. 1

FIG. 2

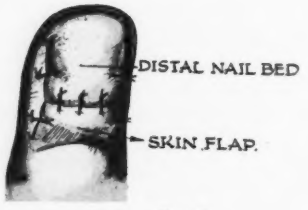

FIG. 3

The skin over the base of the nail bed is raised as a flap (Fig. 1), and the nail is avulsed. The part of the nail bed proximal to the border of the lunula is excised (Fig. 2). The skin flap is advanced and sutured without tension to the cut edge of the distal part of the nail

bed (Fig. 3). If the lateral nail furrows are deep, the lateral nail folds are excised and the skin edges are sutured to the edges of the nail bed.

This operation has been carried out in sixteen cases and the functional and cosmetic results were excellent. In no case was there regrowth of nail; in some there was a little epithelial thickening over the nail bed which was removed easily with a nail brush. In two cases the skin flap was sutured under tension and necrosis of the flap occurred with healing by granulation but this complication should be avoided. If it appears at operation that suture will be possible only under tension it is better to shorten the terminal phalanx. This should also be done if there is a subungual exostosis, or an exaggerated upward curve of the terminal phalanx, because in such cases there would still be shoe pressure against the top of the toe even after removal of the nail bed. When there is infection under the lateral border of the nail, the nail should be avulsed as a first stage and excision deferred for two weeks.

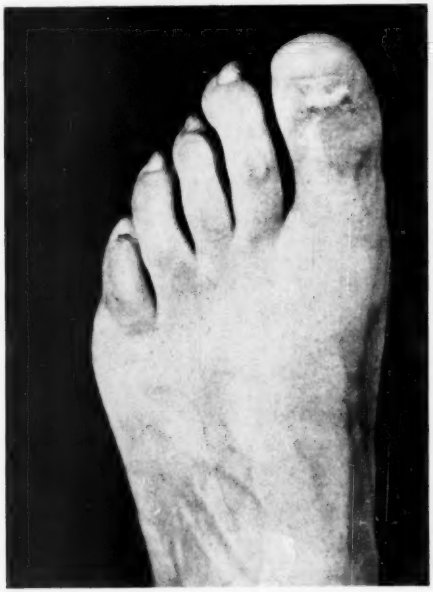

FIG. 4
Result of obliterating nail bed, by the technique described, in a case of onychogryphosis.

The operations were carried out on patients of Mr A. Dornan and Mr F. W. Holdsworth to whom my thanks are due. The figures were drawn by Mr A. S. Foster.

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FOOTBALLER'S ANKLE

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The injury for which I have suggested the title " footballer's ankle " has not, so far as I am aware, been recorded in surgical literature except by Morris (1943). It may be described as an injury peculiar to the professional footballer, especially those over the age of 25 years who have played the game for several years. Footballer's ankle is not, of course, the only lesion of the ankle joint that may be sustained by football players. Strain or rupture of the lateral ligaments, osteochondritis dissecans of the articular surface of the tibia or astragalus, and traumatic tenosynovitis are often seen, just as they are in those who engage in any athletic pursuit; but whereas these other injuries usually follow a single severe injury, footballer's ankle is the result of repeated minor strains of the anterior ligament of the ankle joint. It is characterised by pain and tenderness localised to the area of strain. Radiographic examination shows a bony outgrowth into the capsule of the joint from the anterior margin of the tibia or from the upper surface of the neck of the astragalus.

FIG. 1

Periosteal thickening at the lower end of the tibia, and from the neck of the astragalus, due to the repeated strain of kicking a football with the foot in equinus.

The liability to ligamentous strain arises from the position of plantar flexion in which the foot is held at the moment of contact with the ball, especially when the ball is " dead." A football may be kicked with any part of the foot but in order to control its direction the foot must be held in full equinus to ensure the largest possible area of contact between the foot and the ball. In this position the extensor muscles which normally protect the dorsal capsule of the ankle joint are at a mechanical disadvantage and the strain of the blow is borne largely by the ligament itself. In Association football this position is used constantly in

* This article was received for publication only a few days before the sudden and most unexpected death of Professor McMurray. It was his very last contribution.

kicking the ball; in Rugby football it is used only in drop-kicking. In punting and place-kicking the joint is in less equinus and it is protected by the extensor muscles.

The patient states that he is able to kick the ball as well as ever when using the point of the toe, but when attempting to kick it in the correct manner he feels a sudden stab of pain in front of the joint. There may be slight swelling over the anterior aspect of ankle but swelling is not a characteristic feature and as a rule the appearance of the joint is normal. On palpation there is a point of tenderness in front of the lower margin of the tibia; forced passive plantar-flexion causes pain. The radiographic appearances vary according to the duration of symptoms. In the early stages there may be nothing more than slight periosteal roughening on the anterior aspect of the lower end of the tibia (Fig. 1). Later, a bony ridge may be seen extending forward from the surface of the tibia at the level of attachment of the anterior capsule of the joint. Occasionally a similar bony outgrowth is seen projecting upwards and slightly backwards from the neck of the astragalus. Owing to the position and extent of the bony rim the radiographic appearances are suggestive of osteoarthritis of the ankle joint with lipping of the articular margin of the tibia, but in fact there is no involvement of the articular surfaces and the outgrowth lies slightly above the articular margin which is always clear and unaffected.

CASE REPORTS

Case 1. W. D., aged 27 years—Professional footballer; had played League and International football for nine years.. Complained of increasing pain in the right ankle. Pain arose only when he played and especially when he kicked a " dead " ball; he was able to kick a moving ball with little discomfort. Had been treated for three years by rest, heat and massage, and on one occasion by manipulation. The ankle was swollen. On its anterior aspect there was local tenderness over the articular margin of the tibia. Forced passive movement caused pain. Radiographs showed a large mass of bone extending as a cap over the upper surface of the joint. At operation the bone was found to be within the capsule. The articular surface of the tibia and astragalus showed no roughening. The anterior ligament was detached from the tibia and no attempt was made to reattach it. After operation the joint was rested for four weeks. After three weeks the patient returned to professional football and continued for five years. He retained his former position and his efficiency was in no way impaired.

Case 2. T. J., aged 25 years—Professional footballer; had played League and International football for six years; experienced no discomfort or pain in the ankle until joining the Services and playing for his regimental team, when he found that kicking a " dead " ball caused a stab of pain in front of the ankle. Treated by physiotherapy for three months without improvement. Radiographic examination showed an extensive bony outgrowth from the tibia. A diagnosis of " advanced osteoarthritis of the ankle joint " was entered on his card. He was warned that under no circumstances should he play football again because if he did so he would become a cripple. The bony mass was found at operation to be confined to the capsular tissue from which it was removed. Since operation this man, who is now 31 years of age, has played League and International football consistently for four years with no discomfort.

Case 3. J. D.—Professional footballer. The history and clinical findings were similar to those of the two players already mentioned. Discomfort, pain and tenderness in the ankle had increased for at least two years. Treatment by physiotherapy was given without success. At operation a large mass of bone was removed from the capsule. He played first-class football for five years.

Three other players have been treated in this way with success. None has had to retire from football and all have resumed their former positions. Footballer's ankle can be recognised from the clinical and radiographic appearances. In no case has it been cured by physiotherapy. Operative removal of the abnormal bone mass appears to be the only certain method of cure. After operation full activity can be resumed with confidence.

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PLEOMORPHIC SWEAT-GLAND ADENOMA OF THE FOOT

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From the Wingfield-Morris Orthopaedic Hospital and the Radcliffe Infirmary, Oxford

Tumours of the skin with histological resemblance to pleomorphic adenomata or " mixed tumours " of salivary, lachrymal and mucous glands occur more often than would be suggested by the few reports that have been published. The most recent review of such tumours occurring elsewhere than in the head and neck is by Highman (1944) who collected reports of ten cases described by other authors and added one of his own. The tumour was in the skin of the fingers or hand in seven patients, and more proximally in a limb in four others; the largest was 7·5 centimetres in greatest diameter. The age of the patients was from twenty-nine to eighty years; six were men and five were women. There was no record of recurrence after excision. In only one of the cases reviewed by Highman had the tumour existed for more

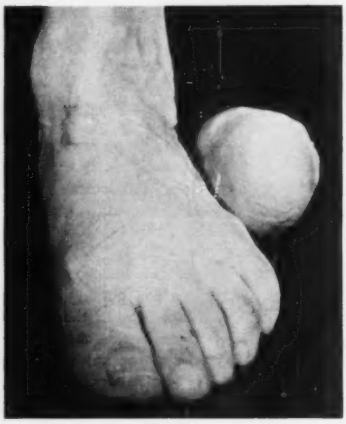

Fig. 1

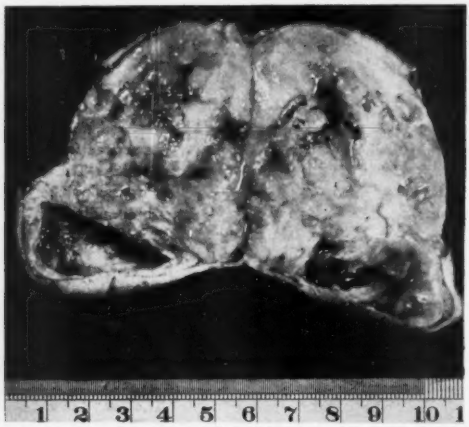

Fig. 2

The tumour before operation (Fig. 1); and the cut surface of the specimen showing multiple cystic areas in a predominantly solid tumour (Fig. 2).

than ten years (Vidari, 1935): this patient had first noticed the swelling in " earliest youth " and he was fifty-eight years old when it was excised.

One case from a series of sweat-gland tumours of this type is reported here because the clinical features were unusual. The tumour had been present for forty years; it was large and pedunculated; and it arose from the foot. So far as we know there is no record of a similar tumour arising in the foot, or of one which was pedunculated. Usually they are firm subcutaneous nodules, well defined and easily enucleated.

CASE REPORT

The patient was an active woman aged eighty-three years who had been aware of a lump on the outer side of the left foot for forty years. At first it was a small nodule but it increased slowly in size. Apart from an occasional ache during wet weather it had caused

little inconvenience except that she had to displace it on to the dorsum of the foot before she could put on her shoe.

On examination—A large tumour was attached to the lateral border of the left foot by a narrow pedicle (Fig. 1). The greater part of the mass was firm but there were a few small cystic areas. The skin over it was thin but mobile and healthy; there was no local tenderness.

Operation—The tumour was removed completely by division of its pedicle. The wound healed soundly and recovery was rapid.

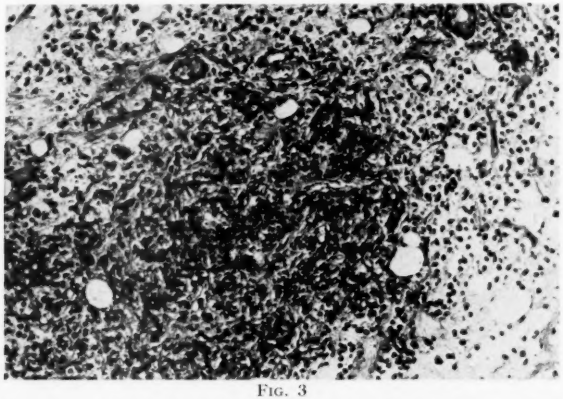

FIG. 3

Closely packed, deeply staining cells (myo-epithelium) surrounding glandular tubules and extending into mucinoid matrix. (Haematoxylin-eosin; ×86.)

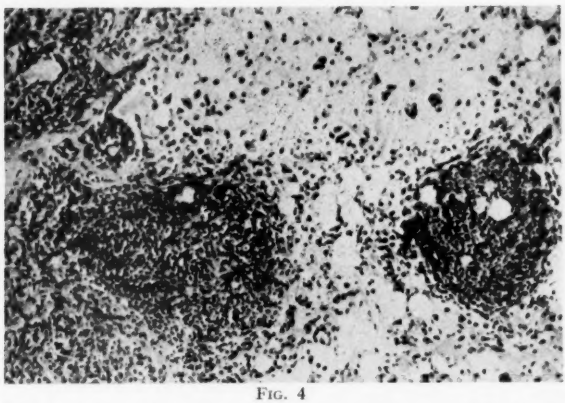

FIG. 4

Cellular area of tumour, consisting of masses of spindle-shaped cells separated by mucinous tissue containing large round cells and fat cells. Hyaline stroma between groups of spindle cells. (Haematoxylin-eosin; ×46.)

Pathology—The tumour was ovoid; it measured $8 \times 6 \times 4{\cdot}5$ centimetres and weighed 98 grammes. It had a smooth surface and was covered with inelastic and slightly wrinkled but freely movable skin which was continued as a covering over the fibrous pedicle, the dimensions of which along the line of surgical division were $3{\cdot}5 \times 0{\cdot}9$ centimetres. Section of the tumour showed that it was partly solid and partly cystic, with a fine fibrous capsule

(Fig. 2). The largest cyst measured 3·5 × 2·5 × 2·5 centimetres and contained yellow mucoid fluid; it was lined with yellow material, partly gelatinous and partly friable. There were several smaller cysts measuring from two to twelve millimetres in diameter. Most of the solid tissue was firm, grey or yellow in colour, and clear mucoid fluid could be expressed from it. A few small lobulated areas had the colour and consistency of adipose tissue. Near the centre of the tumour there was an ill-defined mass, as hard as bone, two centimetres in diameter; beside it was a spheroidal nodule one centimetre in diameter which resembled

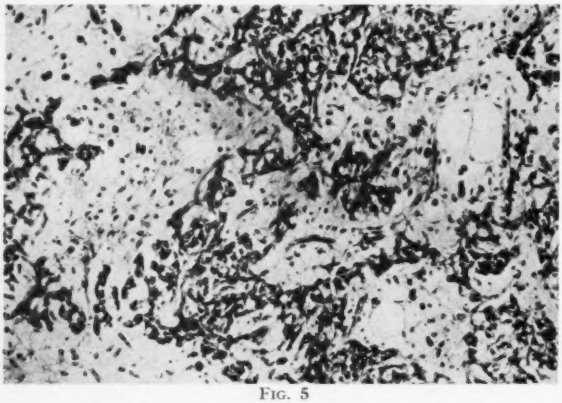

FIG. 5

Myo-epithelial tumour cells in a myxomatoid area. (Haematoxylin-eosin; × 86.)

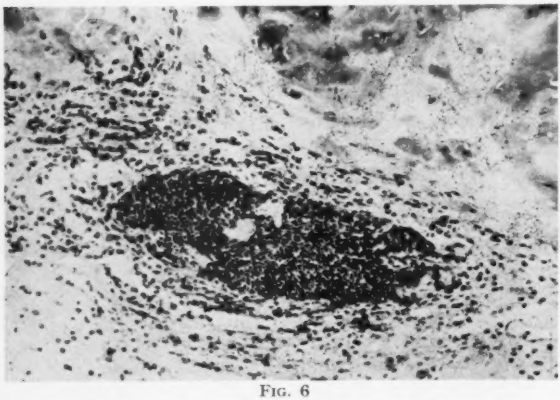

FIG. 6

Cartilage-like tissue and adjacent group of deeply staining spindle cells merging into mucinous tissue. (Haematoxylin-eosin; × 46.)

hyaline cartilage in appearance and consistency. The naked eye appearance was similar to that of a teratoma or of a large salivary tumour of the pleomorphic type.

Histology—The tumour was pleomorphic with a varying degree of cellularity. The more cellular areas were composed of groups of small, deeply staining spindle-shaped cells, closely packed in concentric and interlacing whorls, arranged in some places round tubules lined with a single layer of small, cuboidal or polyhedral, basophile cells (Fig. 3). In a few areas the

tubules were lined with cells of the so called oncocytic type. Some of the spindle-shaped cells were shown to contain longitudinal cytoplasmic fibrils which stained deep blue with phosphotungstic acid haematoxylin. The groups of spindle-shaped cells were separated by an acidophile hyaline stroma which in some areas formed trabeculae between the cell masses but elsewhere expanded into wide zones in which only isolated small clumps of spindle cells were seen. In places the structure was "cylindromatous."

Many of the whorls of spindle cells were surrounded by hyaline trabeculae but others blended gradually with the surrounding tissue which was less cellular (Figs. 4 and 5). This tissue consisted of a mucinoid matrix containing many large rounded cells. The matrix stained metachromatically with toluidine blue, and had a strong affinity for Southgate's mucicarmine and for neutral red when stained by the haematoxylin-neutral-red technique of Duffett (1949). The cytoplasm of the round cells was slightly granular and some of the cells contained material which gave the staining reactions of mucins. Occasional fat cells were scattered throughout the mucinoid areas, and in parts of the tumour there were small islands of mature adipose tissue. In a few areas the structure was myxomatous but elsewhere the matrix was hyaline, faintly basophile and scattered with small round or stellate cells. The rim of matrix surrounding the cells stained more intensely than parts more distant from them and there was a striking resemblance to hyaline cartilage with chondrocytes surrounded by capsules (Fig. 6). There was patchy calcification in this matrix, and the cartilage-like nodule noted in the macroscopic description had a similar structure; the bony hard central mass consisted of densely calcified hyaline trabeculae enclosing large groups of spindle-shaped cells.

Blood vessels were scanty, the larger vessels showed obliterative changes, and there were areas of ischaemic necrosis. The adjacent tumour tissue was less cellular and showed pseudocystic degeneration. The larger cysts were lined with amorphous acidophile material containing lipoid crystals and separated from the surrounding tumour tissue by a layer of acellular hyaline fibrous tissue. No mitotic figures were seen. The tumour had a capsule of condensed fibrous tissue but demarcation from the surrounding dermis was indistinct in some places, and there were groups of tumour cells between the lamellae of the capsule. The dermis was thin and of loose texture with an occasional atrophic sweat gland but no other epidermal appendages. The epidermis showed marked hyperkeratosis and atrophy of the *rete malpighii*.

Comment—The structure of the tumour was that seen in pleomorphic salivary-gland tumours of the predominately myo-epithelial variety. Tubular structures were relatively few in number, and the glandular component of the growth was inconspicuous. The mucinoid and cartilage-like areas, and the dense hyaline stroma of the cellular areas, resembled those seen in salivary gland tumours and there was the same tendency for the tumour to grow through its capsule. There can be no doubt that a tumour of this structure arising in the skin must have originated from the tissue of a sweat-gland.

SUMMARY

The clinical and pathological features of a pedunculated tumour of the left foot in a woman aged eighty-three years are recorded. The tumour had been present for forty years. Histologically, its pleomorphic structure was that of the "mixed tumour" of salivary gland with predominance of the myo-epithelial element. Its origin from sweat-gland tissue is presumed.

We thank Mr W. B. Foley for permission to publish this case and Dr A. H. T. Robb-Smith for his interest. We are indebted to Dr G. A. C. Summers, of Oxford, and Mr Fred Bradley, of the University of Birmingham, for the photomicrographs, and to Mrs Margaret Crossley for the clinical photographs.

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TRANSITORY EOSINOPHILIA LOCALISED IN THE KNEE JOINT AFTER PNEUMARTHROGRAPHY

R. C. MURRAY and ELEMÉR FORRAI, INVERNESS, SCOTLAND

From the Orthopaedic Unit and Clinical Laboratory, Raigmore Hospital, Inverness

Pneumarthrography has been used in the investigation of lesions of the knee joint in more than 200 cases during the past four years. The purpose of this paper is not to discuss the clinical value of this procedure but to record that the introduction of gas into a joint is not, as one might gather from the literature, a process without reaction; there is, in fact, a specific reaction.

In searching the literature we have found only casual references to joint reaction after arthrography. Quaintance (1938) reported fifty cases and made no reference to effusion. Cullen and Chance (1943) noted that there was occasionally a slightly turbid effusion after injecting air; and Hauch (1944), after using oxygen, recorded slight effusion but without noting any abnormal appearance of the fluid at operation. Somerville (1943) observed synovial reaction in eight of thirty cases and concluded that the presence of effusion before injecting air was a factor in causing reaction. In a later communication, Somerville (1946) reported effusion after injecting air in about one-quarter of a much larger series of 331 cases but attributed the reactions to the mildly irritant effect of the air and considered that it was harmless; it was noted that there was no change in the erythrocyte sedimentation rate.

In our own series of cases we observed quite early that effusion often appeared in the joint a few days after injecting air, and at operation the fluid was found to be quite different in appearance from the clear straw-coloured fluid usually associated with a lesion of the meniscus. It was turbid, and on several occasions appeared to be almost purulent. In one early case the resemblance to thin pus was so marked that the operation was almost abandoned; and we began to think that we would never again inject air into a knee joint. However, the cartilage was removed and the patient made an uneventful recovery. Examination of the fluid proved that it was sterile; but the turbidity was found to be due to a high concentration of cells, almost 50 per cent. of which were eosinophils. Subsequently, when a turbid effusion was found at operation it was sent for examination and in nearly every case a high concentration of eosinophils was noted. It was decided therefore to investigate the problem more thoroughly and the investigation has proceeded along two lines of inquiry: *a*) pathological changes as revealed by examination of the synovial fluid, synovial membrane and blood; *b*) clinical effects as shown by the incidence of complications.

PATHOLOGICAL CHANGES IN THE SYNOVIAL FLUID AFTER ARTHROGRAPHY

Normal synovial fluid—The physiology and pathology of synovial fluid and membrane have been studied in detail by Kling (1939). In a normal human knee joint there is from 0·5 to 5 cubic centimetres of transparent, clear, synovial fluid. Turbidity depends upon the number of cells. The total white cell count in normal synovial fluid has been estimated variously as from ten to twenty by Labor and Balogh (1919), from eighty to over 700 by Key (1928) and up to fifty by Kling (1931). The differential white cell count showed a percentage of neutrophil polynuclear cells up to 12 per cent. (Key), 15 per cent. (Kling), 27 per cent. (McEwen); of monocytes 42 to 84 (Key), 0 to 28 (Kling), 5 to 10 (McEwen); of synovial lining cells 0 to 7 (Key), 35 to 60 (Kling). In traumatic effusions the white cell count is given as from 1 to 100 by Julliard (1902), from 5 to 49 by Risak and Winkler (1929), and from 5 to 86 by Kling.

For our purpose it is important to note that eosinophils seldom amount to more than 2 per cent. (Kling). In the acute stage of inflammatory disease, neutrophil polynuclears predominate; whereas in the chronic stage, lymphocytes and monocytes predominate; but prevalence of polynuclears in a case of long duration indicates a progressive process. The *p*H values in normal synovial fluid were recorded by Seeliger (1926) and Pescatori (1930) as being as high as 8·2 to 8·4. The electrometric estimations of Haebler (1929) showed lower values, namely from 6·9 to 7·55, but according to Kling his method was admitted to give values lower than those usually determined. Protein content of the normal synovial fluid was estimated at 0·4 per cent. by Pescatori (1920) and 1·6 per cent. by Fisher (1923). In infected and non-infected synovitis Kling found values varying from 1·39 to 6·92 per cent. with albumin ranging from 1·03 to 3·72 per cent. (average 3 per cent.) and the albumin/globulin ratio from 0·9 to 2. According to Kling the fibrinogen content is low and clotting seldom occurs. When there is irritation or inflammation, permeability of the synovial membrane increases and the protein may exceed blood values. In synovitis of moderate severity the albumin is increased more than the globulin, thus increasing the ablumin/globulin ratio.

Synovial fluid from injured knee joints without arthrography—In this investigation fluid from normal knee joints was not studied, but fluid from thirty-two injured knee joints was examined.* Inflammatory conditions and fluid contaminated by blood were excluded. The cytology of the fluid was found to vary from case to case. In some, polymorphs predominated; whereas in others there was an excess of monocytes and synovial lining cells. At first it seemed difficult to correlate the varying types of cell content with differences in the clinical state but after arranging the results according to the time interval between injury and aspiration a reasonable explanation was found. During the first three weeks after injury, with few exceptions, the neutrophil polymorphs formed a significantly high percentage (20 to 70 per cent.); later lymphocytes, monocytes and synovial lining cells predominated; and after six weeks only an occasional polymorph was found. Six knee joints were aspirated six weeks or longer after injury: in four of the fluids examined no polymorphs were found, and in the other two there was only an occasional polymorph. The cell content was small; but of the cells present, practically all were monocytes, lymphocytes or synovial lining cells. These findings suggest that the time factor determines the nature of the effusion. It must be admitted that there were exceptions even in this small series of thirty-two cases, but perhaps they may be explained by variation in the repetition of minor traumata sometimes causing late appearance of polymorphs and, on the other hand, failure of reaction in cases of chronic derangement of the joint.

One other important finding remains to be mentioned. Of the thirty-two fluids examined from injured joints not subjected to arthrography, eosinophils were found in only three: one was a case of traumatic synovitis aspirated twelve days after injury with 3 per cent. eosinophils (polymorphs 27 per cent.); the second was a proved cartilage lesion and the fluid five days after injury contained polymorphs with an occasional eosinophil; the third was also a proved cartilage lesion and three days after injury there were polymorphs 5 per cent., lymphocytes 30

* **Note on laboratory technique**—The fluids were first seen in the operating theatre and then in the laboratory. A note was made of any abnormality observed on naked-eye inspection, and the fluids were classified as clear, turbid or bloodstained. In the earlier cases the fluids were collected in dry sterile test tubes; but occasionally they were found to be clotted by the time they reached the laboratory: they were, therefore, collected in the theatre in two parts, one in a dry sterile test tube for bacteriological examination, and the other in an oxalate tube.
The results of the *cell counts* were at first unreliable because of the mucous consistency of the fluids which formed precipitates with the usual white cell counting fluid on account of its acetic acid content. After Kling's monograph (1939) had been studied the counting technique was modified according to his experience, using oxalated synovial fluid mixed with gentian violet and saline, and the results were satisfactory. *Differential cell counts* were carried out on smears stained by the Leishman method and haematoxylin-eosin. Neutrophil polynuclears, eosinophils and lymphocytes were easily differentiated, but there was often great difficulty in distinguishing monocytes from synovial lining cells, and these were grouped together. *Protein content* was estimated in a colorimetric way by the biuret method. *Mucin* examination was by Kling's tube and sac method. *The* p*H estimations* were carried out in a colorimetric way based on the Michaelis comparator system.

per cent., monocytes and endothelial cells 55 per cent. and eosinophils 10 per cent. In this last case the eosinophil content is sufficiently high to call for explanation, especially with a polymorph count so low, but this is the only case in which the cytology of the fluid was comparable to that found after the injection of gas. It is worth noting that apart from this case none of the thirty-two specimens was examined less than five days after injury, all earlier fluids having been excluded owing to blood contamination, and it is possible that the production of eosinophils is a normal response of the joint to injury during the first few days only.

Nature of effusion after the injection of air—It was observed clinically that effusion often appeared in the joint after air arthrography, or that pre-existing effusion increased in size. These effusions have been studied in a group of sixty consecutive cases in which the injection of air was followed by exploration of the knee joint. The quantity and naked-eye appearance of the fluid were noted by the surgeon, and microscopic examination was usually made. An effusion is, of course, a common finding when opening a knee joint for a cartilage lesion; but it is our impression that these effusions after air arthrography were greater, and that they occurred with more frequency, as well as being of a different nature. The results of this study are shown in Tables I and II.

TABLE I
NATURE OF EFFUSION AFTER INJECTION OF AIR

Number of cases with effusion		39 (65%)
Turbid effusion	21	
Clear effusion	4	
Not specified	13	
Contaminated with blood	1	
Number of cases with no effusion		13 (22%)
No report as to effusion		8 (13%)
Total		60

In Table I the most striking feature is the frequency of turbid effusions. The turbidity was due to cell concentration and even in fluids described as clear the composition of the cells differed markedly from that of simple traumatic effusion. Polymorphonuclear cells tended to predominate over mononuclear cells, exactly as in the case of any recent traumatic effusion; but the striking feature was the high concentration of eosinophils (Table II). Of thirty-one cases in which fluid was examined microscopically, twenty contained eosinophils ranging from 9 to 75 per cent. (average 35 per cent.). Although most of the fluids examined contained a significantly high percentage of eosinophils, not all of them did, and it was soon observed that the important deciding factor was the time interval between the introduction of air and the removal of fluid at operation. This interval varied from one day to twenty-one days, most of the patients being operated upon between the second and seventh days. All turbid effusions were found during the first nine days after the injection of air. Furthermore, all the fluids with significant eosinophil concentrations were collected between the second and eighth days after injection of air. In thirteen patients no excess of synovial fluid was found at operation: in one, operation was performed the day after arthrography; in six it was delayed until nine to twenty-eight days had elapsed; and of the remaining six patients, study of the arthrogram reveals that in two of them the air was extra-articular.

From this study of sixty cases, it would appear that, with few exceptions, the injection of air into the knee joint gives rise to an eosinophilic effusion; that this requires more than twenty-four hours to make itself shown; and that when the gas is absorbed the joint fluid reverts to normal.

Nature of effusion after the injection of oxygen—In about one hundred cases oxygen has been used instead of air for the purpose of arthrography. Solely on the basis of clinical observation we believe that the synovial reaction is less frequent after the injection of oxygen

TABLE II

CYTOLOGY OF EFFUSION AFTER AIR INJECTION ARRANGED ACCORDING TO TIME INTERVAL BETWEEN INJECTION OF AIR AND OPERATION

Interval: number of days	Number of cases	Number with effusions reported	Number of effusions examined microscopically	Percentage of eosinophils in each case
1	6	4	3	0 0 8
2	10	7	5	17 18 20 25 75
3	6	6	3	1 22 30
4	9	7	6	15 36 51 74 "Majority." Mixed with blood
5	4	3	2	0 25
7	10	5	5	60 54 39 31 14
8	2	2	2	18 0
9	3	2	2	9 0
10	2	1	1	2
11	1	—	—	—
13	1	—	—	—
14	1	—	—	—
16	1	—	—	—
18	1	1	1	0
21	2	1	1	0
28	1	—	—	—
Total . .	60	39	31	

than after the injection of air, and that the effusions that do occur are usually smaller. Oxygen is absorbed from the joint more rapidly than air; the average time of absorption in the case of oxygen is from three to six days, and in the case of air from five to ten days; and this may

account for the more mild reaction. Effusions after oxygen arthrography have been studied in a group of forty patients in whom arthrography was followed by operation and the results are summarised in Tables III and IV.

TABLE III

NATURE OF EFFUSION AFTER INJECTION OF OXYGEN

Number of cases with effusion reported		21 (52%)
Turbid effusion	5	
Clear effusion	12	
Bloodstained	4	
Number of cases with no effusion present		10 (25%)
No report as to presence or absence of fluid		9 (23%)
Total		40

TABLE IV

CYTOLOGY OF EFFUSIONS AFTER OXYGEN INJECTION ARRANGED ACCORDING TO TIME INTERVAL BETWEEN INJECTION OF OXYGEN AND OPERATION

Interval: number of days	Number of cases	Number with effusions reported	Number of effusions examined microscopically	Percentage of eosinophils in each case
1	4	3	3	0 2 3
2	1	1	1	0
3	7	5	5	0 32 46 64 68
4	11	5	5	0 12 40 50 Mixed with blood
5	4	1	1	56
6	5	2	1	25
7	4	3	3	39 38 0
10	1	1	1	0
11	1	—	—	—
12	1	—	—	—
28	1	—	—	—
Total	40	21	20	

It will be noted that effusions were less frequent after injection of oxygen than after injection of air; and examination of the fluid showed that the cell concentration was lower when oxygen was used. Correlated with this is the lower incidence of turbid effusions. When

oxygen was used, five of twenty-one effusions were turbid (24 per cent.); when air was used, twenty-one of thirty-nine effusions were turbid (54 per cent.). Of the five turbid oxygen effusions, four were found on the third day and one on the seventh day after arthrography. Microscopic examination revealed differential counts similar to those already described after injecting air. Of the twenty effusions examined, eleven (55 per cent.) had eosinophil counts ranging from 12 to 68 per cent. (average 42·7 per cent.), and these were all found between the third and seventh days after injecting gas. From these findings it is reasonable to conclude that the reaction caused by oxygen injection is essentially similar in nature to that produced by injecting air.

Other synovial fluid investigations—Comparable biochemical data in the air and oxygen cases are as follows:

Total protein . .	after air arthrography . . .	4·25% to 5·0%
	after oxygen arthrography . .	4·0 % to 5·0%
Albumin . . .	after air arthrography . . .	3·45% to 4·0%
	after oxygen arthrography . .	3·2 % to 4·0%
Globulin . . .	after air arthrography . . .	0·5 % to 1·0%
	after oxygen arthrography . .	0·8 % to 1·4%

*p*H ranged between 7·0 and 7·2

PATHOLOGICAL CHANGES IN THE SYNOVIAL MEMBRANE AFTER ARTHROGRAPHY

Specimens of synovial membrane were removed at operation from seven knees after air arthrography and from six knees after oxygen arthrography and the sections were examined by Dr H. J. Kirkpatrick. The characteristic feature was a low grade inflammatory process with infiltration of round cells, and in eleven of the thirteen sections eosinophils were present in unusually large numbers. Sections taken from four knees not subjected to arthrography showed no eosinophils. It is worth noting that in only two of the seventeen cases was the pathologist previously informed whether or not arthrography had been performed.

General reaction—With one exception there was no pyrexia after arthrography in approximately 200 cases. This one case was due to infection and will be referred to later. *Blood sedimentation rate*—Thirteen cases investigated: in ten, there was no significant change; in three, the rate rose from 1 to 8, from 7 to 17, and from 9 to 17 (Wintrobe method). *White cell count*—Sixteen cases investigated: in eight there was a significant rise, one from 7,250 to 15,200 and another from 9,000 to 16,200. *Differential white cell count*—Fourteen cases investigated: no significant change observed.

CLINICAL EFFECTS OF ARTHROGRAPHY

Reports of complications after arthrography are few. Schoedel, quoted by Chauvin and Bourde (1925) suggested the possibility of persistent synovitis, gas embolism and sudden death; but Oberholzer (1936) described more than 1,000 cases from Bircher's Clinic without a single complication. The only serious complication we have been able to find reported in the literature is one case of non-fatal pulmonary embolism recorded by Kleinberg (1921). In our series of approximately 200 cases there was one complication. A tense effusion appeared on the second day after injecting air; the temperature rose to 100·6 degrees, the knee was acutely painful, and a diagnosis was made of pyogenic arthritis. Purulent fluid was aspirated from which a non-haemolytic streptococcus was cultured. The injection subsided after repeated aspiration and chemotherapy, but recovery of function was slow. The complication might have been more serious, but considering the large number of cases in which this method of investigation has been used it must be agreed that arthrography is not a dangerous procedure.

The question arises as to whether the eosinophilic reaction described in this paper is of no more than academic interest, or whether it is of clinical significance. In order to determine whether or not it is harmful, two series of cases have been compared: in one series, meniscectomy was preceded by injecting air in sixty cases and oxygen in forty cases; and in the other series meniscectomy was performed without first injecting any gas. The incidence of complications in the two groups of cases are summarised in Table V.

TABLE V
COMPLICATIONS AFTER MENISCECTOMY

	No gas	Air arthrography	Oxygen arthrography
Number of cases . . .	50	60	40
Average age (years) . . .	29·6	25·4	28·2
Average time in hospital (days) .	36	34	38
Persistent effusion . . .	7	9	4
Slow recovery of movement .	3	8	3
Haemarthrosis	—	—	1
Complications	10 (20%)	17 (28%)	8 (20%)
No complications . . .	40 (80%)	43 (72%)	32 (80%)

It will be noted that the incidence of complications is slightly higher in the group of patients whose knee joints were injected with air than in the other two groups; but the difference between 28 per cent. and 20 per cent. is not significant in a relatively small series. Nevertheless if the complications after air injection are analysed in relation to the type of effusion found in the joint at operation the result is interesting (Table VI).

TABLE VI
INCIDENCE OF COMPLICATIONS IN RELATION TO TYPE OF EFFUSION

Complication	Turbid effusion	Other effusion	No effusion	Not stated
	21 cases	18 cases	13 cases	8 cases
Persistent effusion. . .	6	1	2	—
Slow recovery of movement .	4	2	—	2
Total . . .	10 (48%)	3 (17%)	2 (15%)	2 (25%)
No complication . . .	11 (52%)	15 (83%)	11 (85%)	6 (75%)

The striking feature of this analysis is that ten of seventeen complications occurring after meniscectomy preceded by air arthrography occurred in cases in which a turbid effusion was observed in the joint at the time of operation. Nearly half these cases with a turbid effusion were in fact complicated. There is a marked contrast between these figures and the group of thirteen cases in which there was no effusion at the time of operation: eleven (85 per cent.) were uncomplicated and only two (15 per cent.) were complicated.

Though the number of cases is small we think it justifiable to deduce that air arthrography does tend to increase the incidence of complications if operation is performed during the stage of eosinophil effusion. If this is accepted it follows that when air is employed for the purpose of arthrography, operation should be carried out either the day after injection, before the eosinophil effusion has made its appearance, or that it should be delayed until

the tenth day by which time the reaction should have subsided. It is possible that the risk of complication may be minimised by withdrawing the air from the joint after radiography, as described by Rechtman (1929) and Simon, Scott Hamilton and Farrington (1936). From our experience, however, we advise that oxygen should be used instead of air because it is absorbed more quickly, there is less joint reaction and there are fewer post-operative complications.

DISCUSSION

Localised and transitory eosinophilic infiltration of the synovial membrane with transitory eosinophilia of the synovial fluid has been shown to occur after pneumarthrography. Eosinophilia has been observed in different clinical conditions and efforts have often been made to produce it experimentally in animals; but, so far as we know, localised tissular eosinophilia has not previously been produced experimentally in humans, and in this respect some of our findings may be of significance. In particular we suggest that through experimental production of eosinophils in the knee joint by injecting gas, an important and easily accessible technique is available by which to pursue research on the causes of eosinophilia.

The subject is discussed extensively by Dérobert in his important book (1942), by Hajos and Rajka in their monograph (1944) and in the papers of Löffler (1936, 1947) and Kirk (1938). One of the most debated questions has been the origin of eosinophil cells. Most authors agree that generalised eosinophilia originates from bone marrow, but it remains to be seen whether tissular eosinophilia depends on the tissues themselves. Localised eosinophilia has been recorded by Muller (1889) in the sputum of asthmatic patients, and by other writers in the nasal secretions of allergic rhinitis. It has been observed also in pleurisy with pneumo-thorax, which is comparable in some respects with air arthrography of the knee for in both there is effusion associated with air under pressure.

Liebreich (1921) produced increase of eosinophils in blood by mixing it with anticoagulants and storing it for a few days. We tried the same experiment with synovial fluids from the knee joint mixed with anticoagulants. We stored them at zero temperature, room temperature and 37 degrees centigrade in an incubator for one to seven days and examined the number of eosinophils daily. There was no change in the number of eosinophils in fluids which showed marked eosinophilia, and no eosinophils appeared in fluids where there were only neutrophils.

Changes in the physico-chemistry of tissues, especially lowering of the pH and disturbance of the protein equilibrium, have been considered as factors responsible for localised eosinophilia. In our cases the pH moved between 7 and 7·2, which is rather on the acid side considering the known alkalinity of normal synovial fluid; but it is not significant. Increase of albumin is another factor that has been held to be responsible for localised eosinophilia and several writers have said that in eosinophilic pleurisy the pleural fluid contains albumin with little or no globulin. In synovial effusions of moderate severity albumin is increased to greater degree than globulin, and the albumin/globulin ratio is higher than normal. In the cases we investigated the globulin was always below 1 per cent.; and the ratio, which is normally below 2, moved up to between 4 and 5.

When Hajos and Németh (1927) investigated experimental eosinophilia produced in the lungs of guinea pigs by inhalation of atomised horse serum their observation showed that, after a latent period of about twelve to twenty-four hours, eosinophils appeared in the capillaries of the lung and infiltration could be found only after the first day. In our experiments, the appearance of eosinophils after a latent period of two days bears a strong resemblance to Hajos's observations. This period of latency led Hajos to believe that in his cases of anaphylaxis the eosinophils were not poured out from the bone marrow but were formed in the tissues.

To summarise, it can be said that after introducing air or oxygen into the knee joint, localised inflammation occurs with the appearance of many eosinophils in the synovial membrane and fluid. This eosinophilia is localised and does not appear in the blood; it

coincides with disturbance of the protein equilibrium of the synovial fluid; it is not connected with any marked change of acidity; it lasts from the second to the ninth day after the introduction of gas; and during this time the joint is more sensitive to surgical interference. It could not be established whether the appearance of eosinophils was primarily in the synovial membrane or in the synovial fluid; nor could the origin of the tissular eosinophilia be traced; but the period of latency observed by others in animal experiments shows a striking resemblance to our results. The conditions are similar to those when tissue split-products are absorbed from an exudate, especially under raised pressure of air. So far as we know this is the first experimental production of localised transitory eosinophilia in human beings.

SUMMARY

1. Study of 200 cases investigated by pneumarthrography has shown that the introduction of air or oxygen into the knee joint is followed by a specific reaction characterised by transient localised eosinophilia in synovial membrane and synovial fluid.

2. Complications after meniscectomy seem to be more frequent when operation is performed during the phase of eosinophil reaction.

3. The significance of these observations has been discussed in relation to other causes of eosinophilia and it is suggested that this method of local production of eosinophils may be of experimental importance.

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THE SENSITIVITY AND INNERVATION OF THE ARTICULAR CAPSULE

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There is still uncertainty as to the relative importance of bone, cartilage, ligament and synovial membrane as sources of pain in joint disease. It is agreed that articular cartilage is devoid of nerves and gives rise to no sensation when it is stimulated. The bone ends play an important part in the appreciation of vibratory and other mechanical stresses and they may contribute to the pain of disease because periosteum is highly pain-sensitive; and moreover cancellous bone may be sensitive though to a lesser degree. On the other hand, the sensitivity of fibrous articular ligaments and synovial membrane has been disputed and the contribution made by these structures to joint sensation is uncertain.

The earliest attempt to assess the sensitivity of human articular capsule was made by Sappey (1889) who found that synovial membrane attached to the stump of a disarticulated limb was insensitive to traction. He concluded that joint sensation resided in the articular ligaments; we must recognise, however, that the nerve supply to the synovial membrane which he examined must have been damaged seriously by the disarticulation. In 1900 Bloch examined the joints of conscious patients on whom he was operating and observed that the articular capsule and ligaments of healthy joints were completely insensitive. On the basis of similar clinical studies Lennander (1906) arrived at the opposite conclusion and said that normal ligaments and synovial membrane were equally and highly sensitive to electrical, chemical and mechanical stimuli. This view was supported by Foerster in 1927. Nyström (1917) noted a regional variation in the sensitivity of the capsule of the human knee joint: he found that it was insensitive above the femoral condyles but sensitive near its attachment to the medial semilunar cartilage. He noted also that the "inner joint surfaces," including presumably the synovial membrane, were insensitive. Leriche (1930) and Brunschwig and Jung (1932) argued that joint sensitivity was entirely a periarticular phenomenon because they found that the pain of a sprained joint could be relieved by infiltrating the ligaments with a local anaesthetic whereas intra-articular injections were ineffective. Kellgren (1939), in a general survey of deep sensibility, found that fibrous capsular ligaments were sensitive to mechanical and chemical stimuli; and when aspirating fluid from the knee joint he noted that the subject experienced pain "when the needle impinged upon the lining of the suprapatellar pouch." Davies (1945) explored a knee joint under local anaesthesia and stated that synovial membrane remote from the incision was insensitive to pressure, but that it was acutely sensitive to a needle prick, which caused acute diffuse pain on the same side of the joint. Thus, there is considerable disagreement as to the sensitivity of synovial membrane and fibrous articular ligaments.

Deep sensibility has been separated into two main types, namely, pain and pressure, the latter including sensations of tension and of vibration and movement. Observations on punctate sensibility, and dissociation experiments, suggest that these sensations are carried by different types of nerve fibre (Heinbecker, Bishop and O'Leary 1934, Lewis and Pochin 1938, Weddell and Harpman 1940, Kellgren and McGowan 1948). We have therefore studied pressure as well as pain sensibility in the knee joints of normal human volunteers and of patients undergoing arthrotomy under local anaesthesia, and we have combined these studies with detailed examination of the innervation of human and feline knee joints.

* The cost of the anatomical research was defrayed by a grant from the Medical Research Council.

SENSORY EXPERIMENTS

Sensibility of the capsule—Observations were made upon the knee joints of five normal volunteers. A small intra-cutaneous wheal of procaine was raised over the medial collateral ligament at the joint level and a hypodermic needle was passed through the anaesthetic skin into the underlying ligament. Any consequent sensation was noted. The needle was then withdrawn from the ligament and, by sliding the skin over the underlying capsule, it was reinserted at intervals of 2·5 millimetres for a distance of 1 centimetre in each of four directions. Testing at some of the spots gave rise to pain, at others to a sensation only of pressure and at some to no sensation at all. In this way a chart was constructed showing the distribution of sensitive and insensitive spots and, in the case of sensitive areas, the quality of response in terms of pain or pressure. The procedure was repeated over the patellar ligament and also over the medial and lateral parts of the joint capsule at the level of the proximal margin of the patella. Although there was variation in pattern from part to part, and in different subjects, the number of sensitive and insensitive spots varied little from one subject to another. The findings are summarised in Table I.

TABLE I

NUMBER OF SENSITIVE AND INSENSITIVE SPOTS FOUND IN THE EXPLORED AREAS OF FIBROUS LIGAMENTS OF THE KNEE JOINT IN FIVE NORMAL HUMAN SUBJECTS

Sensibility tested with a needle point at intervals of 2·5 millimetres

Sensation aroused	Medial ligament	Patellar ligament	Medial capsule	Lateral capsule	Total
Pain	48	36	29	34	147
Pressure	10	16	28	15	69
None	27	33	28	36	124

Three hundred and forty spots were tested: less than half gave rise to no sensation at all; nearly half gave a sensation of pain; and sixty-nine spots gave a sensation only of pressure. Thus the fibrous capsular ligament of the knee joint contains numerous spots which give rise to sensations of pain, of pressure, or of both, when stimulated with a needle point. If a larger area of ligament is stimulated by the injection of 6 per cent. saline the subject invariably feels pain, though its severity varies with the part tested.

Sensibility of the synovial membrane—The synovial membrane is not normally accessible to this type of investigation but observations were made on five patients with early arthritic changes in the knee joint who were undergoing diagnostic arthrotomy. After injecting a minimal volume of anaesthetic into the skin and fibrous ligament the joint was opened by a vertical incision about 2 centimetres from the medial or lateral border of the patella. With adequate retraction a view was obtained of the suprapatellar pouch, the surroundings of the patella, and the synovial membrane lining the femoral condyles and the capsule at the sides of the joint.

The exposed synovial membrane was stimulated by pricking, by scratching with a needle, and by crushing and pulling with artery forceps, care being taken to avoid grasping tissues other than synovial membrane. Although it proved impossible to test synovial membrane with the same accuracy as articular ligaments the membrane was explored systematically, each stimulus being applied four or five times to different parts of each area. Most of these stimuli produced no sensation at all. In only two patients was pain evoked by the needle prick and the sensitive region was limited to a small area close to the upper margin of the patella. Even massive stimuli such as pulling and crushing in artery forceps produced sensation only from scattered areas of the synovial membrane lining the sides of

the articular capsule. The quality of these sensations varied: in four patients slight pain was felt " somewhere in the knee "; in two of these, and in the fifth patient, the sensation had a " pulling " or " pushing " quality. Some of the membrane lining the sides of the capsule could not be stimulated under direct vision, and it was always possible that the jaws of the forceps had stimulated the fibrous capsular ligament inadvertently; thus the sensations of pain and " pulling " experienced when this region was stimulated may not have been of true synovial origin.

A critical experiment—These observations are open to the criticism that the synovial membrane in these patients may have been abnormal. Moreover the results were complicated by the vague and variable terms which many patients used to describe their sensations. It was difficult, for example, to know what was meant when a patient said that the sensation was " nothing much." It was decided therefore to carry out a more critical experiment upon a subject trained to discriminate between different types of sensation. One of us (E. P. S.) volunteered to have his knee explored for this purpose. The left knee joint was opened by a vertical incision one and a half inches long, situated one inch from the lateral margin of the patella. The incision was made at a lower level than that usually employed for arthrotomy in order to give such access to the joint cavity as to permit stimuli to be applied under direct vision. The synovial membrane was pricked and scratched with a needle, crushed and pulled with artery forceps, and finally injected with 0·3 cubic centimetres of 6 per cent. saline.

Pricking and scratching the synovial membrane gave rise to no sensation at all except at one or two localised areas at its reflexion from the capsule, low down near the joint line. Crushing the lining of the suprapatellar pouch caused no sensation except in one isolated region on the medial side of the joint; and the same was true of stimuli applied to the membrane on each side of the patella. Near the upper border of the patella a sensitive area was located which gave rise to a diffuse, deep pain of moderate intensity felt in front of the knee. Some areas of the membrane lining the sides of the joint were insensitive to crushing, but a few scattered areas in these regions gave rise to some diffuse pain localised with variable accuracy to the stimulated side of the joint. The effect of traction and distortion varied according to the degree and the region stimulated. Manipulations that caused only distortion of the synovial membrane produced no sensation; but when the tension was sufficient to cause movement and dimpling of the overlying skin there was a sensation of pressure which was localised accurately to the skin dimple. This sensation was identical with that felt when pressure was applied to the appropriate skin area over the joint, and was clearly caused by stimulation of the more superficial structures. The injection of 0·3 cubic centimetres of 6 per cent. saline into the suprapatellar pouch evoked no sensation, but injection into the synovial membrane on the lateral side of the joint caused diffuse, deep pain of mild intensity localised to the lateral side of the knee and the vastus lateralis muscle. Findings in the healthy knee joint of a trained subject were therefore essentially the same as those in patients with diseased joints.

Discussion—In the six subjects who were investigated the synovial membrane lining the upper part of the knee joint was largely insensitive, though there were a few scattered spots along the upper border of the patella and at the sides of the joint which gave rise to slight pain when crushed with artery forceps, and on one or two occasions pain was produced by a needle prick in these regions. No sensations of pressure or tension were noted during stimulation of the synovial membrane provided that there was no spread of stimulus to the overlying ligaments and skin. The synovial membrane is thus a relatively insensitive structure and differs markedly from the fibrous ligament which is intensely sensitive and contains numerous spots which, when stimulated with a needle point, give rise to sensations of pressure, pain or both. The quality and distribution of pain arising from the synovial membrane is similar to that of pain arising from the fibrous ligament.

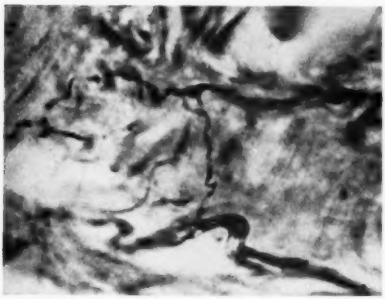

FIG. 1

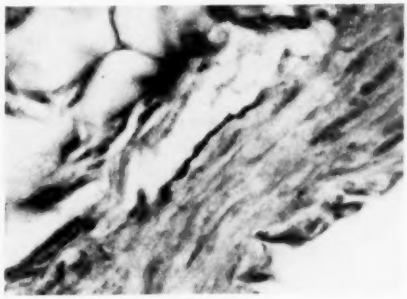

FIG. 2

FIG. 3

Normal cat (transverse section of articular capsule, Romanes stain, ×900). Figure 1 shows non-medullated fibres ramifying in the adventitia of a blood vessel in the junctional tissue. Figure 2 is a section of an artery in the fibrous capsular ligament with a non-medullated fibre in the tunica media. Figure 3 shows a capillary in the synovial membrane with a fine non-medullated nerve terminating in four branches with bead-like endings.

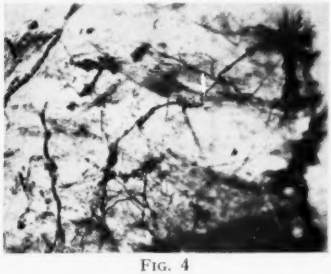

FIG. 4

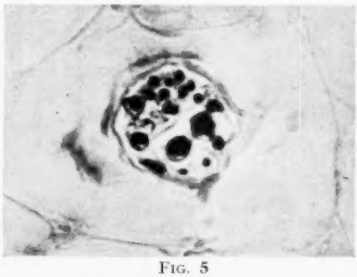

FIG. 5

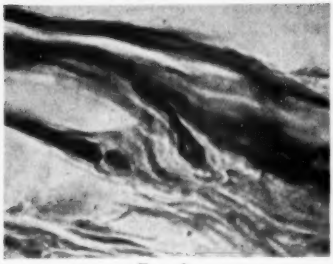

FIG. 6

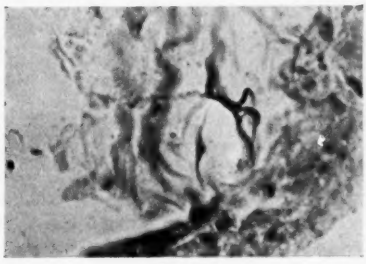

FIG. 7

Sympathectomised cat. Figure 4 is a whole tissue preparation of the synovial membrane showing the delicate plexus of nerve fibres (Cajal stain, × 175). In Figure 5 is seen a small nerve bundle in the inner layers of the fibrous capsular ligament with coarse and fine medullated and non-medullated fibres persisting after sympathectomy (Romanes stain, ×900). Figure 6 shows a coarse non-medullated nerve terminating in a loop, and Figure 7 a non-medullated nerve ending in a complex loop just below the free surface of the synovia (×900).

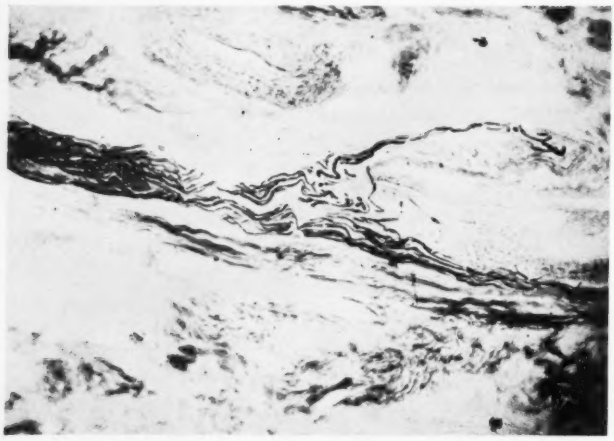

FIG. 8

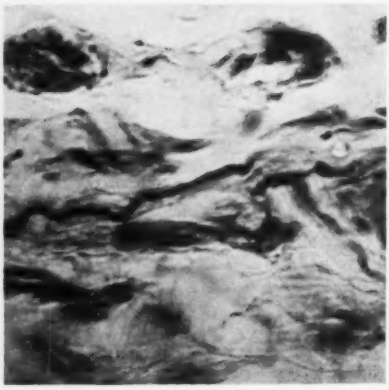

FIG. 9

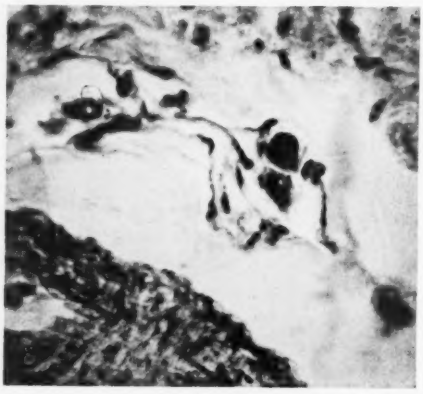

FIG. 10

Normal human knee joint. Sections of the articular capsule showing, in Figure 8, a large neurovascular bundle dividing in the capsular ligament (Romanes stain, ×100). In Figure 9 a nerve fibre is seen pursuing a sinuous course on the vessel wall (×550). Figure 10 shows a dichotomously branching nerve fibre terminating in bead-like endings close to the wall of a capillary (×900).

To compare our findings with those of other workers it is necessary to know which areas of synovial membrane they explored. This information was provided only by Lennander (1906) who stated that synovial membrane behind the ligamentum patellae, at the sides of the patella on each side of the joint, and investing the cruciate ligaments, was highly pain-sensitive. We are unable to comment on the sensitivity of the membrane behind the ligamentum patellae and surrounding the cruciate ligaments, but we did not find that synovial membrane at the sides of the patella and at the sides of the joint was equally and highly sensitive in all parts. Accordingly we cannot agree with the statements of Lennander (1906), and Davies (1945 and 1946), that the synovial membrane is everywhere a highly pain-sensitive structure; nor do our observations substantiate the views of Bloch (1900), Nyström (1917) and Leriche (1930) that the synovial membrane is completely insensitive. It appears that the truth lies somewhere between these two views. The synovial membrane is a relatively

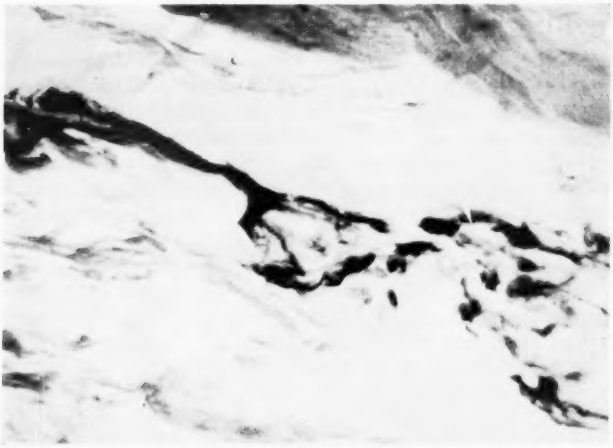

FIG. 11

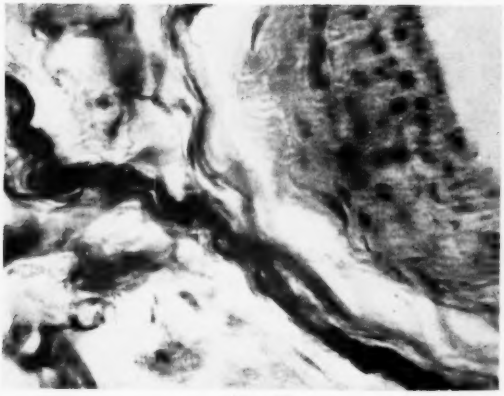

FIG. 12

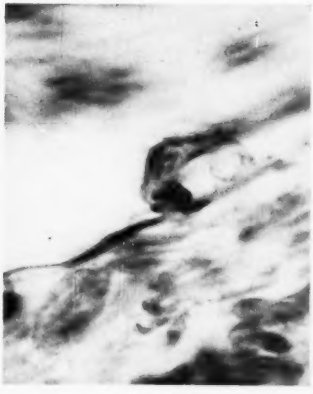

FIG. 13

Normal human knee joint. Figure 11 shows a plexus of non-medullated fibres in the inner layers of the fibrous capsular ligament (Romanes stain, ×550). In Figure 12 is seen a nerve bundle running close to the synovial surface (×550). Figure 13 shows fine nerve fibres ending in bead-like terminals in the synovial membrane (×900).

insensitive structure with a few pain-sensitive spots which are surrounded by wide areas from which no sensation can be aroused either by mechanical or chemical stimuli.

ANATOMICAL STUDIES

Sensory investigations are unsatisfactory unless they are viewed against a background of appropriate anatomical knowledge. Most investigators have agreed that fibrous capsular ligaments receive a rich supply of medullated and non-medullated nerve fibres but few have agreed upon the character, manner of distribution or mode of termination of the nerves within the synovial membrane. Köllicker (1853), Oda (1935) and Gardner (1942, 1944 and 1948) maintained that all synovial nerves were closely associated with blood vessels; whereas Rüdinger (1857), Hagen-Torn (1882), Sfameni (1902), Sigurdson (1930), Gerneck (1932), Sunder-Plassmann and Daubenspeck (1938), MacConaill (1942), Freyberg (1944) and Davies

(1945 and 1946) described a plexus of non-medullated nerves in the synovial membrane apart from vascular nerves. Many authors have said that the nerves in synovial membrane are autonomic in origin but no direct evidence has been presented.

One of us (E. P. S.) made an extensive histological study of the innervation of the human knee joint and the knee joint of the cat. A detailed account will be published elsewhere but the more important findings may now be summarised. Twenty normal knee joints were studied by examination of whole-tissue preparations, and razor sections stained by the methods of Romanes, and Bodian and Cajal as modified by Gooding and Stewart. To determine the autonomic and somatic constituents of the innervation of articular capsule, the knee joints of 120 normal cats were compared with those of eighteen cats upon which sympathectomy had been performed. Twelve of the latter had been subjected to unilateral lumbo-sacral sympathectomy and ipsilateral femoral periarterial sympathectomy; in the remainder, bilateral lumbo-sacral and unilateral femoral periarterial operations had been performed. After allowing time for post-ganglionic degeneration the knee joints were examined by the staining methods mentioned above.

By comparing the findings in animals with and without sympathectomy an estimate was made of the contribution made by the autonomic system to innervation of the joint (Figs. 1 to 7). In the knee joint of the cat most nerves of all types enter the capsule in association with blood vessels and form neurovascular bundles, so that the general pattern of innervation of the fibrous ligament and synovial membrane is influenced by the pattern of the vascular tree. Articular nerves of somatic origin are both medullated and non-medullated, and they form the major part of the non-medullated nerve plexus found in the deeper layers of fibrous ligaments. They also make a small contribution to the similar but more delicate nerve network found in synovial membrane. Many fibres of somatic origin terminate in fibrous capsular ligaments and the junctional tissue which lies between the ligament and the synovial membrane. These fibres may terminate in encapsulated endings, blunt endings of various shapes or in free unspecialised endings. Some fibres of somatic origin also penetrate to the synovial membrane where they terminate in nerve loops, globular endings or simple unspecialised endings. Some of the fibres accompanying the arterioles, and some that terminate in the adventitia of larger vessels, also appear to be somatic in origin. Fibres of autonomic origin give rise to the plexus which is found between the tunica media and the tunica adventitia of blood vessels and those embedded in the media itself. Most of the fibres which accompany arterioles and capillaries in the synovial membrane and terminate in bead-like endings close to the vessel walls are also of autonomic origin. The autonomic fibres also form that part of the delicate nerve network which results from migration of nerve fibres from one vessel to another in the synovial membrane.

Fibrous articular ligaments are richly supplied with nerves, largely somatic in origin. Synovial membrane is less richly supplied with nerves and a large proportion of the synovial nerves appears to be autonomic in origin. Synovial membrane does, however, contain a substantial number of nerves which are somatic in origin and terminate in nerve loops, globular endings or simple unspecialised endings.

The innervation of normal human articular capsule resembles that of the cat very closely (Figs. 8 to 13), but we have been unable to examine any sympathectomised human material; so that no statement can be made as to the relative proportion or distribution of the somatic and autonomic components in man.

DISCUSSION

If we now consider together the anatomical and sensory observations it is clear that, in the knee joint, fibrous articular ligaments are richly supplied with nerves of various types, and that then ligaments are densely studded with spots which give rise to sensations of pain

or pressure when stimulated mechanically. The fibrous ligaments therefore play an important role in articular sensation and appear to be the major source of joint pain. The synovial membrane on the other hand is less richly supplied with nerves and is a relatively insensitive structure in which only occasional spots can be found which give rise to a sensation of pain. Synovial membrane is not a major source of articular sensation and probably contributes little to the symptoms of joint disease. This accords with clinical observations that ligamentous sprains are painful whereas synovitis is often painless.

Both fibrous ligament and synovial membrane contain a variety of nerve endings. Although we have at present no means of correlating function with morphology, it seems unlikely that all synovial endings can represent pain receptors and vasomotor nerves, and it is interesting to speculate on the possible function of some of the globular and loop-shaped endings which are found in synovial membrane.

SUMMARY

1. Pain and pressure sensibility has been studied in the fibrous articular ligament and synovial membrane of the knee joint in normal human subjects and in patients subjected to arthrotomy under local anaesthesia.

2. The fibrous ligament was found to be a highly sensitive structure, containing many spots which give rise to sensations of pain or pressure when stimulated mechanically or chemically. Synovial membrane was found to be a relatively insensitive structure which only occasionally contains pain-sensitive spots.

3. Histological examination of articular capsule from the knee joints of normal and sympathectomised cats shows that articular ligaments have a rich nerve plexus and a variety of specialised and unspecialised nerve endings, most of which are somatic in origin. Synovial membrane contains a more delicate nerve network and also a variety of nerve endings, the majority of which are autonomic in origin. But a substantial number of somatic nerves enter the synovial membrane, some of which terminate in nerve loops, globular endings or simple unspecialised endings.

4. Histological examination of normal human articular capsule shows that its innervation closely resembles that of the cat, but no sympathectomised human material was examined.

5. The bearing of these findings on the symptomatology of joint disease is discussed briefly.

We are indebted to Professor G. A. G. Mitchell, Director of the Anatomical Research Laboratories, Manchester University, for facilities to carry out the histological work; and to Mr Gooding and Mr P. Howarth for preparation of the illustrations.

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THE POPLITEUS MUSCLE AND THE LATERAL MENISCUS

With a Note on the Attachment of the Medial Meniscus

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Study of the anatomy of the human popliteus muscle has shown not only that many present descriptions are faulty but also that the muscle may play an essential and hitherto unrecognised part in protecting the lateral meniscus from injury. The description of the

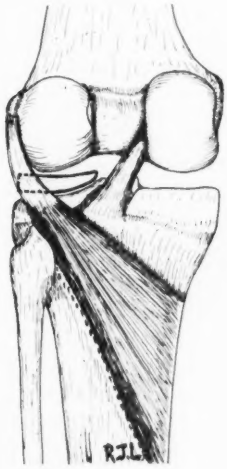

FIG. 1

The popliteus muscle as it is described in current texts. The muscle is not shown to be attached to the lateral meniscus. The ligaments of Humphry and Wrisberg are not recognised in modern terminology.

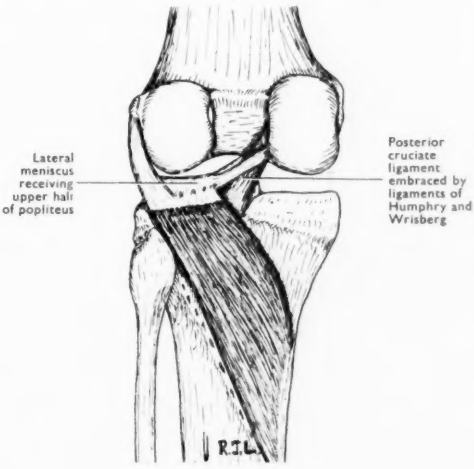
Lateral meniscus receiving upper half of popliteus
Posterior cruciate ligament embraced by ligaments of Humphry and Wrisberg

FIG. 2

In fact, the *upper* half of the muscle is inserted into the posterior arch of the lateral meniscus and the meniscus is attached to the femur by the ligaments of Humphry and Wrisberg. Contraction of popliteus draws the meniscus backwards during rotation of the knee.

popliteus muscle in more than a dozen current British text-books is that of a rounded tendon passing from the lateral epicondyle of the femur to a fan-shaped fleshy attachment to the popliteal surface of the tibia (Fig. 1). The tendon is sometimes said to lie free in the cavity of the knee joint, surrounded by a synovial sheath that herniates out beneath the fleshy belly as the popliteus bursa; and it has been said to bevel the posterior edge of the tibial plateau. In reality, no less than half the muscle is attached by a quadrilateral aponeurosis to the posterior arch* of the lateral meniscus and this half has no attachment to the femoral tendon; the quadrilateral aponeurosis receives direct insertion of the muscle fibres of the medial or upper half of the muscle (Fig. 2).

An occasional variant is shown in Figure 3. Here the meniscal aponeurosis arises from the deep surface of the popliteus across its whole width. In such cases the superficial fibres of the muscle converge, and are attached to the femoral tendon; while the deep fibres act by

* The term " arch " in this paper refers to the circumference of a meniscus, excluding both anterior and posterior horns.

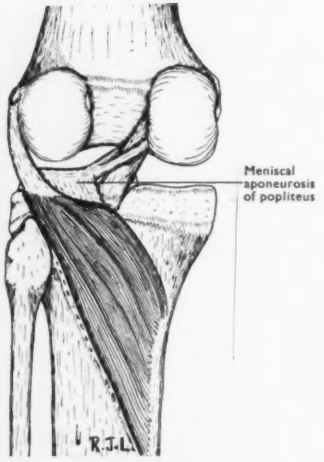

FIG. 3

An occasional variant. The superficial fibres of popliteus converge to the femoral tendon. Across the whole width of the muscle the deep fibres are attached to the aponeurosis which is inserted into the posterior arch of the lateral meniscus. Contraction of the popliteus draws the meniscus backwards during rotation of the knee.

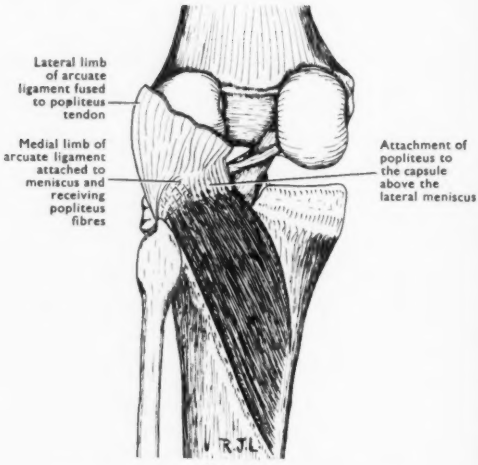
Lateral limb of arcuate ligament fused to popliteus tendon
Medial limb of arcuate ligament attached to meniscus and receiving popliteus fibres
Attachment of popliteus to the capsule above the lateral meniscus
R.J.L.

FIG. 4

Capsular attachments of popliteus. The arcuate ligament is attached to the lateral meniscus. Superficial fibres of the *lower* half of popliteus are inserted into it; contraction of these fibres depresses the arcuate ligament, which in turn draws the posterior arch of the meniscus downwards. The meniscal aponeurosis of popliteus shown in Figures 2 and 3 is covered by a sheet of fibres by which the popliteus is attached to the posterior part of the capsule over the femoral condyle.

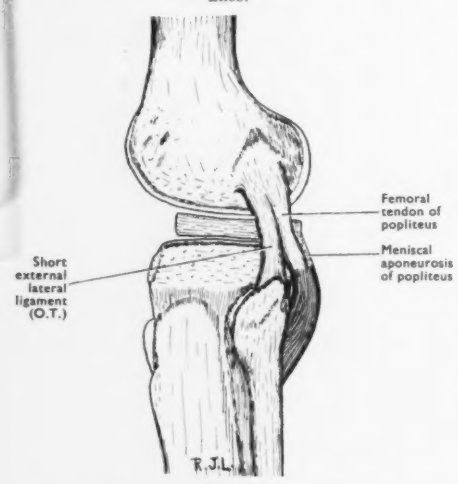

FIG. 5

The femoral tendon of popliteus. The lateral ligament of the knee is removed to show the short external lateral ligament of Old Terminology; it is fused to the anterior edge of the popliteus tendon. It is as strong as the lateral ligament; yet it is unrecognised in modern nomenclature.

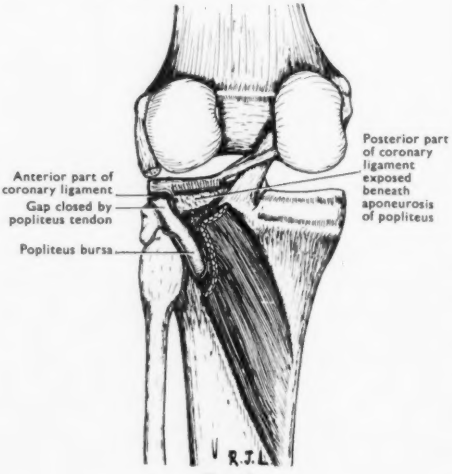
Posterior part of coronary ligament exposed beneath aponeurosis of popliteus
Anterior part of coronary ligament
Gap closed by popliteus tendon
Popliteus bursa
R.J.L.

FIG. 6

Popliteus muscle divided to expose the popliteus bursa. It lies beneath the femoral part of the muscle. Division of the meniscal (upper) half of the popliteus has exposed the coronary ligament and synovial membrane; there is no popliteus bursa here.

way of the aponeurosis directly on the lateral meniscus. It may be that failure to notice such a deeply placed aponeurosis accounts for the error in many descriptions, because in such cases the aponeurosis can easily be cut from the deep surface of popliteus, leaving an apparently free upper border to the muscle.

In both the normal muscle and the occasional variant, fibres from the posterior surface of the muscle cover the meniscal aponeurosis and are continued up to blend with the capsule behind the lateral femoral condyle (Fig. 4). Similarly, in each case, there lies deep to the aponeurosis the weak and lax coronary ligament lined with synovial membrane attaching the inferior border of the lateral meniscus to the edge of the articular surface of the tibia. The coronary ligament is part of the true capsule of the knee joint (Fig. 6). These attachments of the popliteus to the lateral meniscus and to the capsule of the knee joint are recognised by continental authors, though none seems to have noted the functional significance of the arrangement. Such attachments are suggested too in a few English text-books but only in the illustrations where these have been reproduced from former editions and in no case can the description be found in current English texts.

The arcuate ligament is variously described. Some texts record it as arching from the fibular styloid over the popliteus muscle to blend with the oblique posterior ligament of Winslow; whereas others say that it extends from the lateral condyle of the femur to the posterior part of the capsule, being convex downwards and attached to a triangular retinaculum extending from its convexity to converge on the fibular styloid. In truth, there is at this part of the capsule such a complexity of fibres running in many directions that, by artful dissection, almost any pattern desired by the dissector could be made! By far the strongest and most consistent of these fibres form a triangular sheet that diverges upwards from the fibular styloid. The lateral limb of this mass is dense and strong, and it is attached to the femur and the popliteus tendon; while the weaker medial limb curves over the popliteus muscle, is attached to the posterior arch of the lateral meniscus and thence passes upwards to be lost on the posterior part of the capsule. The free edge of this medial limb is crescentic and beneath it the lateral, or femoral, part of the popliteus emerges to approach its tibial attachment. The attachment of the superficial fibres of the muscle to this concave edge is scarcely noted in current texts, but it is this attachment that serves to displace the arcuate band downwards and so draw the posterior arch backwards, as can be shown in an unfixed specimen by pulling downwards the superficial fibres of the lateral part of the muscle (Fig. 4). The essential facts about the functional anatomy of the arcuate ligament are that it is attached to the lateral meniscus, and, that part of the popliteus is inserted into it.

As stated, the upper or medial half of the popliteus muscle is inserted by an aponeurosis directly into the posterior arch of the lateral meniscus and has no connection with the femoral tendon of attachment. Moreover, superficial fibres of the other part are attached to the arcuate ligament and it will thus be appreciated that more than half the cross-sectional bulk of the muscle belly of the popliteus acts entirely on the posterior arch of the lateral meniscus and has no attachment at all to the femur. In the occasional variant illustrated in Figure 3 the deep half of the muscle acts on the lateral meniscus, and only the superficial half acts on the femur.

TENDON OF POPLITEUS

The posterior margin of the medial condyle of the tibia is right-angled in shape, and the articular area is confined to the upper horizontal surface of the tibia. The posterior margin of the lateral tibial condyle is rounded and the articular surface is continued downwards over the sloping area. Inspection makes it evident that the rounded bevel is caused by the posterior arch of the lateral meniscus, and not by the tendon of popliteus, which in no position of the knee joint comes into contact with this part of the tibia. The popliteus tendon makes no more than a narrow oblique groove at the postero-lateral angle of the tibial margin just above the styloid process of the fibula. Furthermore, the tendon of popliteus does not lie free

within the cavity of the knee joint but is firmly attached along its lateral surface to the joint capsule which, here, is very strong and consists of the lateral limb of the arcuate ligament described above. Fused to the popliteus tendon at its femoral attachment is the upper end of the powerful " short external lateral ligament " (of Old Terminology, non-existent in modern nomenclature). The lower end of this ligament diverges from the popliteus tendon and is inserted into the styloid process and medial border of the head of the fibula. It is blended with the capsule of the joint in front of the popliteus tendon and, morphologically, has been deemed to be a thickened part of the capsule. It serves functionally to reinforce the lateral ligament of the knee joint with which indeed it is equal in strength (Fig. 5). Sometimes, however, it is absent. Only the medial surface of the popliteus tendon projects into the joint cavity, producing a ridge which is covered with synovial membrane above and below the meniscus. There is sometimes a further attachment of popliteus to the meniscus by fibrous strands directly connecting the tendon to the meniscus where the two are in contact between the synovial reflections above and below the meniscus. Usually, however, there is no such attachment and the meniscus is grooved by the passage across it of the rounded tendon. The synovial membrane below the meniscus herniates deep to the lateral or femoral part of the muscle as the popliteus bursa. There is no popliteus bursa beneath the medial or meniscal part of the muscle, for here the joint is closed by the attachment of the coronary ligament to the edge of the articular facet on the tibial plateau (Fig. 6).

LIGAMENTS OF HUMPHRY AND WRISBERG

The ligaments of Humphry and Wrisberg were well known to former generations of anatomists. Perhaps because their names have been omitted from B.N.A. and Birmingham revision nomenclature their existence goes unnoticed in many current texts; and particularly is this so of the ligament of Humphry. They are strong fibrous bands which embrace the posterior cruciate ligament and connect the posterior arch of the lateral meniscus to the medial condyle of the femur in the intercondyloid fossa (Fig. 2). In man only a small part of the posterior horn of the lateral meniscus is attached to the tibia; and in most animals the posterior horn has no tibial attachment, being held only by the ligaments of Humphry and Wrisberg to the femur. In many of these animals sudden rotary movements of the knee must be a vital necessity. On the other hand, among the Cheiroptera, the genus Pteropus (the fruit bat) have knees in which the movement of rotation is completely lacking, only flexion and extension being possible. These animals have no menisci and no popliteus muscle, which is confirmatory evidence of the purely rotatory function subserved by these structures (Parsons 1900). The function of the ligaments of Humphry and Wrisberg in holding the posterior arch in a constant relation to the rotating femur is believed by this writer to be an integral part of the mechanism of control of the lateral meniscus.

ACTION OF POPLITEUS

In flexion and extension of the knee joint, movement takes place in the upper compartment, above the menisci. It seems certain that the essential action of popliteus on the knee joint is that of rotation. In the hyperextended or so-called " locked " position of the joint it is indeed the only muscle that can have a rotatory effect. In flexion and extension of the knee joint the axis of rotation of the femoral condyle passes so nearly through the attachment of the popliteus tendon that any flexing effect of the muscle must be negligible. In the flexed position of the joint the rotators are the hamstrings, contracting alternately, and it is suggested that during such rotation the popliteus functions not merely as an accessory muscle of rotation, but essentially as a controller of the position of the lateral meniscus.

In the hyperextended or " locked " position of the knee joint it is only the popliteus muscle that has any rotatory effect because in this position any one hamstring can act on the knee joint only as a flexor. In beginning the movement of " unlocking " the hyperextended

knee joint, the popliteus rotates the lateral condyle of the femur and draws it posteriorly on the lateral facet of the tibia. During this rotary movement the ligaments of Humphry and Wrisberg serve to draw the mobile posterior arch of the lateral meniscus in a medial direction. This movement alone would tend to flatten the posterior arch and render it liable to crushing between the femur and tibia; but simultaneously contraction of the popliteus draws the posterior arch backwards and downwards over the rounded posterior margin of the lateral tibial facet, thus maintaining its original curvature and drawing it out of harm's way. In the rotary movement of " unlocking " the hyperextended knee the movement of the lateral meniscus is minimal. In rotary movements of the flexed knee, however, the excursion of the femoral condyles on the tibial plateau is symmetrical and of considerable extent, as can be felt readily by anyone who examines his own knee. Here the range of movement of the posterior arch of the lateral meniscus is likewise considerable, and produces the bevelling of the posterior margin of the tibial condyle which has been attributed erroneously to the popliteus tendon.

This writer believes that it is not the mobility of the lateral meniscus that protects it from injury so much as the precisely controlled movements imparted by the ligaments of Humphry and Wrisberg, and the meniscal fibres of popliteus, thus ensuring that in all positions of the joint the posterior arch is held away from the millstones of the femur and tibia so that it cannot be ground between them. An attachment between the femoral tendon and meniscus, which is sometimes present, serves further to hold the meniscus in a constant relation to the rotating femoral condyle. Other fibrous bands that are occasionally seen between the lateral meniscus and the popliteus, or the posterior cruciate ligament, would act similarly. By reason of the elasticity of the meniscus the position of the anterior arch is dependent on that of the posterior arch. Thus, when the lateral condyle of the femur moves anteriorly on the tibial plateau, relaxation of the ligaments of Humphry and Wrisberg and of the popliteus muscle allows the posterior arch to glide forwards, and the anterior arch does likewise as the meniscus resumes its position of rest.

Text-books of surgery all note that injuries are sustained more often by the medial than by the lateral meniscus; and they give the proportion variously as four to one, five to one or even up to twenty to one. Many give no explanation of this fact, and those that do try to explain it assume that the lateral meniscus is protected by its mobility, though often the observation is qualified by such words as " possibly " or " probably." It is well known that mobile bodies within the joint are liable to impaction between the femur and tibia, and it is difficult to imagine why the mobile lateral meniscus should be an exception. Apart from direct violence, injuries to the menisci are produced exclusively during rotation movements of the flexed knee. The medial meniscus is fixed by its horns to the tibia, and by its whole circumference to the coronary ligament. It is attached also to part of the medial ligament of the knee joint and is thus *relatively* immobile on the tibia; and injury to the medial meniscus presupposes such injury as distraction, momentary stretching or rupture of the capsule or medial ligament. The lateral meniscus, on the other hand, is held but loosely by the capsule, which is here called the coronary ligament, and although its horns are connected to the tibia its whole circumference is freely mobile. When the lateral meniscus is injured it can therefore be assumed that the fault lay in the mechanism whereby the popliteus muscle normally controls its position; there may be no injury at all to the ligament or to other articular structures. In the same connection it is interesting to note that locking of the joint often occurs after rupture of the medial meniscus but seldom after injury to the lateral meniscus. In the case of the medial meniscus the torn part is uncontrolled and may be impacted between the femur and tibia; whereas in the case of the lateral meniscus the torn fragment may still be controlled by the popliteus and, though abnormally mobile, is pulled away from the femur during rotation of the knee. Mobility of loose bodies and ruptured medial menisci often causes locking of the joint by inclusion between the articular surfaces; but mobility of the lateral meniscus never causes locking because it is a *controlled* mobility.

NOTE ON THE MOBILITY OF THE MEDIAL MENISCUS

Of the strength of attachment of both horns of the medial meniscus to the tibia there is no doubt; a strong ligament holds each horn firmly fixed to the tibia. There seems to be some misunderstanding, however, as to the degree of fixation of the circumference of the meniscus to the articular margin of the tibia. Actually there is no firm attachment to the tibia, and the periphery of the meniscal arch is attached much more firmly to the femur than to the tibia by both superficial and deep parts of the medial ligament.

The superficial part of the medial ligament is triangular in shape. The vertical anterior border of the ligament is not attached to the meniscus; but the oblique upper and lower fibres of its posterior border converge on the meniscus and are firmly attached (Fig. 7). This area of attachment lies posterior to that of the deep part of the medial ligament described below. The fibres from the femur to the meniscus are short and they pull the arch of the

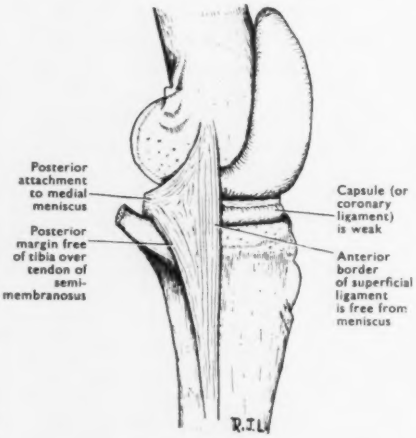
Posterior attachment to medial meniscus
Posterior margin free of tibia over tendon of semi-membranosus
Capsule (or coronary ligament) is weak
Anterior border of superficial ligament is free from meniscus
R.J.L.

FIG. 7

The attachments of the medial meniscus. The superficial medial ligament is attached posteriorly to the medial meniscus. The short femoral fibres move with the femur; the long tibial fibres are free from the tibia over the semimembranosus expansion and the medial inferior genicular vessels. In rotation of the knee, therefore, the arch of the medial meniscus moves with the femur on the tibia.

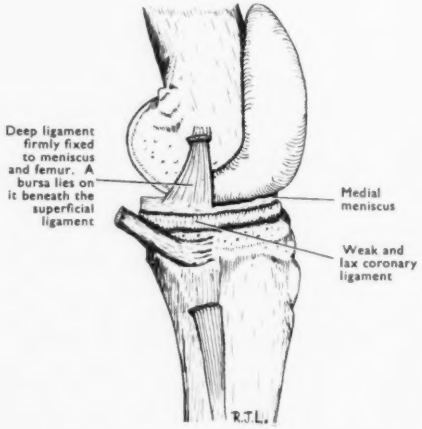
Deep ligament firmly fixed to meniscus and femur. A bursa lies on it beneath the superficial ligament
Medial meniscus
Weak and lax coronary ligament
R.J.L.

FIG. 8

The attachments of the medial meniscus. The superficial medial ligament is removed. The deep medial ligament (short internal lateral ligament of Old Terminology) is attached from femur to medial meniscus. Between the meniscus and tibia there is only lax and weak coronary ligament. *The medial meniscus is not attached firmly to the tibia except at its horns.* The arch of the meniscus moves with the femur during rotation of the knee.

meniscus forwards when the femur rotates laterally on the tibia. The fibres from the tibia to the meniscus are not only much longer but are separated from the upper margin of the tibia by the underlying expansion from the semimembranosus tendon and, lower down, by the medial inferior genicular vessels. In lateral rotation of the tibia on the femur these fibres therefore do not have the same effect on the arch of the meniscus; the tibial condyle slides forwards beneath the ligament and fails to move the arch of the meniscus, which remains stationary on the femur.

The deep part of the medial ligament lies hidden beneath the superficial part and is largely separated from it by an intervening bursa. It forms a strong connection between the femur and the medial meniscus, into which it is strongly inserted (Fig. 8). It is a thickening of the capsule, with which its anterior and posterior fibres blend. It is the " short internal lateral ligament " of Old Terminology. It is scarcely represented below the level of the

medial meniscus, which is attached to the tibia here by a weak coronary ligament that is no stronger than that around the remainder of the arch. In rotation of the knee the short fibres of the deep ligament, like the oblique fibres of the superficial part, ensure that the arch of the meniscus follows the femur and moves with it on the tibia.

It is fallacious to argue that rupture of the medial meniscus is due to its fixation to the medial ligament and thus to the tibia; the arch of the meniscus is surprisingly mobile on the tibia in rotary joint movements. But the mobility, unlike that of the lateral meniscus, lacks muscular control and is purely passive. It is accompanied, moreover, by greater distortion than in the case of the lateral meniscus which is more circular and less widely fixed to the tibia at its horns. The medial meniscus sustains rupture not because it is fixed to the tibia but because its arch is mobile on the tibia, and because its movement lacks the control mechanism of the lateral meniscus.

SUMMARY

1. The movements of flexion and extension at the knee joint take place above the menisci; the movements of rotation take place below the menisci.

2. The popliteus muscle consists of two halves, one being attached by tendon to the femur, the other by aponeurosis to the lateral meniscus. The action of the muscle is to rotate the knee and retract the posterior arch of the lateral meniscus. The flexing action of the muscle is quite negligible.

3. The effects of rotation of the knee joint on the two menisci are dissimilar. The *medial meniscus* is distorted during rotation; its horns move with the tibia, but the intervening arch moves with the femur, and the distortion renders it liable to injury during rotation. The *lateral meniscus* does not become distorted during rotation; it follows the lateral condyle of the femur by reason of the attachments of the ligaments of Humphry and Wrisberg and the popliteus muscle. It is thus relatively immune from injury during rotation.

Note on dissections—The dissections upon which this article is based are in the Museum of the Royal College of Surgeons of England. Most of them have been made recently by the Prosector, D. Tompsett, Ph.D., in collaboration with the writer.

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THE USE OF RADIOACTIVE PHOSPHORUS IN THE DIAGNOSIS OF AVASCULAR NECROSIS OF THE FEMORAL HEAD

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Mechanical factors have now been excluded as the main cause of non-union in fractures of the femoral neck: the development of efficient methods of internal fixation has removed this source of non-union and the chief remaining cause is disturbance of the circulation of blood to the capital fragment. The incidence of avascular necrosis of the femoral head appears to depend upon normal variations in the vascular pattern and also upon the severity of the vascular injury (Kolodny 1925, Wolcott 1943, Tucker 1949). It is possible that delayed vascular occlusion may play a part; but the vascular damage is usually sustained at the time of the original injury, although it may perhaps be increased by inadequacy of immobilisation, violence of manipulation and by the effects of some forms of internal fixation.

It is a striking fact that there may be a mass of avascular bone in the body without any means of distinguishing it clinically or radiographically from living bone. This is true particularly during the first few months after fracture of the femoral neck with vascular occlusion; there is no reliable clinical evidence as to the viability of the femoral head. Eyre-Brook and Pridie (1941), in reporting a series of such fractures, noted that avascular necrosis of the capital fragment did not develop when the fracture-shaft angle was greater than 37 degrees; but apart from this observation there is little evidence on which the diagnosis can be based and each fracture is an enigma. The surgeon must wait for several months, or even for several years, before the fate of the head can be predicted with certainty.

THE RELATIONSHIP OF PATHOLOGICAL TO RADIOGRAPHIC CHANGES IN AVASCULAR NECROSIS OF BONE

The first result of loss of blood supply to bone is death of the cellular components—osteoblasts, osteoclasts and marrow cells. Calcified intercellular substance is not a living tissue—it is the inert product of osteoblasts—and for this reason, death of bone does not produce immediate change in its radiographic density. After injury, and the disuse that follows injury, there is usually deossification of living bone; and since dead bone cannot share in this vital process differences in radiographic density may be observed when dead and living bone are compared. The contrast in density depends largely upon the degree of immobilisation that is maintained, and to a lesser extent upon the local reactions of bone to injury. Now that internal fixation is used so generally, and early functional activity is encouraged, such atrophy of disuse is minimised and there is therefore no certain contrast, and perhaps no contrast at all, between living and dead bone.

Axhausen (1922) showed that when bone was avascular the organic matrix gradually lost its strength and resistance. Under the pressure of weight-bearing the degenerated trabeculae were liable to fracture and compression, and bone dust accumulated in the marrow spaces. Such collapse of cancellous bone is the usual cause of true increase of the density of avascular bone—a change that becomes evident radiographically from three months to three years after injury. Moreover, like other dead tissues, dead bone may attract calcium salts from surrounding fluids thus accounting for increase in density when the bone is not crushed and compressed but retains its original contour.

In time, an inflammatory response develops in adjacent living tissue: the avascular fragment is invaded by granulation tissue; the bone matrix is eroded by osteoclastic components; and new bone is laid down on the remaining trabeculae. Such regeneration is,

of course, slow. Phemister (1939) said that " substitution of the dead portion by the living bone may gradually take place and in from one and a half to three years it may be complete." This slow process of revascularisation with erosion of trabeculae can be traced in radiographs by the extending area of reduced density during which time there is an increasing tendency to collapse under the strain of weight-bearing.

THE PROBLEM OF EARLY DIAGNOSIS OF AVASCULAR NECROSIS

The fate of the femoral head is usually determined at the time of injury; and, if there is complete loss of blood supply, every attempt to restore normal function must fail. How then can a reliable indication of the vascularity of the femoral head be gained within a few days of fracture? At first, attempts were made to determine whether or not there were living cells by removing bone with a trephine and studying the cell structure; but this never gave conclusive evidence when carried out within a few days of injury. Supravital staining of bone and marrow cells was also attempted but it proved to be unreliable. Attention was therefore directed to measures by which the arterial supply to bone could be demonstrated. The injection of non-toxic chemicals and dyes, such as fluorescein, was rejected by reason of the difficulties of detection and the lack of sensitive reaction. The method finally selected was the intravenous injection of radioactive isotopes which are carried by the blood stream to all tissues with a normal blood supply. Demonstration of the isotope in a given tissue proved that the circulation was normal, or at least that there was absorption from neighbouring vascular tissues. After fracture of the neck of the femur, comparison of concentration of the isotope in the femoral head with that of a control bone such as the trochanter in which the blood supply was known to be normal, gave an indication of the residual vascularity of the femoral head. Theoretically, vascularity could be assessed most accurately if the isotope was retained in the blood stream so that the radioactive content of a unit mass of bone would be an accurate index of the active vascular bed in the bone. Such an isotope is not yet readily available. In this investigation radioactive phosphorus was used —a safe and readily available isotope which is a normal metabolite showing a tendency to accumulate in bone.

Radioactive phosphorus has the same physical and chemical properties as ordinary phosphorus but is distinguished from it by the emission of β rays which can be detected. The half-life of radioactive isotope P^{32} is 14·3 days which is long enough for our purpose. Moreover, the rate of radioactive decay is constant under all conditions; the β rays are absorbed by the tissues, 0·1 millimetres of tissue absorbing about 90 per cent. of the rays (Hamilton and Soley 1939). By placing the ashed tissue near a Geiger counter the radioactivity of the sample can be measured accurately. The number of counts recorded from 1 gramme of tissue in one minute gives an assessment of the content of P^{32} in the tissue. It is necessary to subtract a predetermined number of counts, known as the " background count," due to the recording of cosmic rays on the Geiger counter.

For a given dose of P^{32} the amount of radioactive phosphorus deposited in a unit quantity of bone is variable and seems to depend on the vascularity of the bone, its composition and the time interval between injection and assay. Since the relative proportions of bone, red marrow and fatty marrow vary in the individual, and from one area of bone to another, it will be appreciated that the amount of radioactive isotope accumulating in bone in a given time will vary according to the tissue composition. Red marrow contains more phosphorus than fatty marrow and both these components are difficult to separate from the bone tissue. For this reason, small variations are to be expected between any two specimens.

METHOD OF INVESTIGATION

Radioactive phosphorus was obtained in the form of disodium phosphate in aqueous solution. It was diluted with normal saline and sterilized by autoclaving. Investigations

were first undertaken in rabbits. The dose employed was 50 microcuries injected into an ear vein. Operations on the neck of the femur and ligamentum teres were performed before injection of the isotope. Two hours after injection, a fragment was removed from the femoral head and also from a neighbouring bone the blood supply of which was known to be undisturbed. The details of the experiments, which were undertaken by Professor H. L. Sheehan, will be understood from three representative examples.

Experiment 1—Under anaesthesia the femoral neck was divided close to the trochanter and 50 microcuries of radioactive phosphorus in 0·8 millilitre of disodium phosphate were injected into an ear vein. Both femoral heads were excised two hours later and assayed:

	Femoral head subjected to operation	Normal femoral head as control
Weight of bone	0·626 gm.	0·461 gm.
Total weight of ash	0·245 gm.	0·168 gm.
Ash for assay	0·166 gm.	0·165 gm.
Count per minute	621	757
Count/gm. wet bone/min.	1450	1675

Ratio of isotope in the femoral head on the side of operation, as compared with normal control bone, 1 : 1.

Experiment 2—Under anaesthesia the right femoral head was dislocated and the ligamentum teres divided. One hour later 50 microcuries of radioactive phosphorus in 0·8 millilitre of disodium phosphate solution were injected into an ear vein. Two hours later both femoral heads were excised and assayed:

	Femoral head on the side of operation	Opposite femoral head as control
Weight of bone	0·383 gm.	0·583 gm.
Weight of ash	0·143 gm.	0·180 gm.
Ash for assay	0·134 gm.	0·169 gm.
Count per minute	509·6	549·2
Count/gm. wet bone/min.	1420	1005

Ratio of isotope in the femoral head on the side of operation, as compared with normal control bone, 1 : 1.

Experiment 3—Under anaesthesia the right femoral head was separated from its blood supply by division of the femoral neck and division of the ligamentum teres. The head was replaced in the acetabulum, the wound closed, and 50 microcuries of radioactive phosphorus in 0·8 millilitre of disodium phosphate were injected into an ear vein. Both femoral heads were excised two hours later and assayed:

	Femoral head on the side of operation	Normal femoral head as control
Weight of bone	0·389 gm.	0·323 gm.
Total weight of ash	0·149 gm.	0·166 gm.
Ash for assay	0·143 gm.	0·121 gm.
Count per minute	152	1300
Count/gm. wet bone/min.	407	5540

Ratio of isotope on the side of operation, as compared with normal control bone, 1 : 14.

These three experiments indicate that basal fracture of the femoral neck alone, and division of the ligamentum teres alone, does not alter the vascular supply to the femoral head in rabbits; but that when all vascular connections to the femoral head were severed

TABLE I

ANALYSIS OF THIRTEEN FRACTURES OF THE NECK OF THE FEMUR INVESTIGATED BY INJECTION OF RADIOACTIVE PHOSPHORUS

Patient	Initials and age of the patient in years	Type of fracture	Date of operation	Dosage of radioactive isotope P^{32} in c.c.	Time between injection of isotope and removal of bone sample	Radioactive emanation per minute/gramme		Ratio of isotope content	Clinical result
						Head	Trochanter	Head : Trochanter	
1	M. H. 69	Basal neck	9. 9.47	135	4 hours	722	730	1 : 1	Viable head. Union
2	M. E. J. 70	Subcapital	16. 9.47	287	3 hours	97·9	*	1 : 16	Avascular necrosis
3	M. C. 83	Mid/cervical	7.10.47	150	2 hours	63	680	1 : 10·9	Avascular necrosis
4	A. W. 68	Subcapital	13. 1.48	100	30 minutes	324	204	3 : 2	Viable head. Union
5	S. K. 65	Subcapital	19. 1.48	100	5 minutes	134	225	1 : 1·6	Viable head. Pin migration
6	E. P. 78	Subcapital	4. 2.48	110	25 minutes	32·2	97·7	1 : 3	Viable head. Poor pinning. Non-union
7	A. B. 59	Subcapital	9. 2.48	120	45 minutes	37·5	18·5	2 : 1	Viable head. Union
8	E. C. 70	Subcapital	16. 2.48	200	1 hour	1265	1385	1 : 1	Viable head. Union
9	M. M. 68	Subcapital	16. 2.48	175	1 hour	593	336	2 : 1	Viable head. Extrusion of pin
10	W. H. 69	Subcapital	22. 3.48	175	90 minutes	188	182	1 : 1	Viable head. Union
11	W. J. 54	Subcapital	3. 5.48	165	1 hour	40·7	218	1 : 5	Segmental avascular necrosis
12	E. M. C. 48	Mid/cervical	4. 5.48	150	1 hour	444	196	2·3 : 1	Viable head
13	R. M. 18	Slipped epiphysis	4. 5.48	150	2 hours	164	325	1 : 2	Viable epiphysis

* In this case a sample was not removed from the trochanter, and a control was not therefore available. But on consideration of the dosage of P^{32}, and the time interval between administration of the isotope and removal of the bone, the *minimal* count to be expected would give a ratio of 1 : 16.

by division of both these structures, absorption of radioactive material dropped to a very low level so that the ratio of content in the femoral head on the operated side was only one-fourteenth that of bone with a normal blood supply.

The detection of some radioactive phosphorus in the dead head may appear to contradict the very principles involved; but it is explained adequately by absorption of radioactive phosphorus from the surrounding haematoma and synovial fluid. For this reason negative counts on the Geiger counter are unlikely to be obtained even when the bone is completely avascular. Nevertheless if a bone sample is removed from the centre of the bone within an hour of administration of the isotope, absorption from the surrounding tissue fluids should be minimal.

The method applied to human cases—In humans the isotope was injected into the antecubital vein, the usual dose being from 150 to 200 microcuries. A sample of bone was

FIG. 1

FIG. 2

Case 2. M. E. J. There is radiographic evidence of avascularity of the femoral head in the increasing penetration of the nail through the relatively dense head (Fig. 2); but this evidence became available only after two years. At the time of the original operation the content in the femoral head of radioactive phosphorus injected intravenously was estimated at one-sixteenth that of normal bone, thus proving avascularity.

removed from the head of the femur after reduction of the fracture and the insertion of a guide wire by which to direct the three-flanged nail used for internal fixation. A quarter-inch drill hole was made, concentric with the guide wire, down to the fracture line, preferably in the posterior and inferior quadrant of the neck; and a calibrated three-sixteenths inch trephine, six inches in length, was passed along the drill hole and hammered or rotated into the proximal fragment. The position of the trephine was checked radiographically in two planes before it was driven into the head, and radiographs were also taken after final insertion, in order to confirm that the sample was obtained from the proximal fragment. The fragment of bone thus secured was sprayed immediately with saline or water to remove surface blood, and dried on a piece of gauze. A piece of cancellous bone was also removed from the greater trochanter by a similar technique. Both specimens were assayed for radioactive content.

Specimens weighing from 100 to 150 milligrammes were usually obtained. The specimen was weighed accurately, ashed, spread evenly on a small paraffin-coated paper tray, and the radioactive content assayed by a Geiger counter. The pulses of the counter were recorded on a scale-of-hundred unit (Rotblat *et al.* 1948). Each specimen was examined on three occasions for a period of twenty minutes and the average reading was calculated. By further calculation the activity per gramme of wet tissue per minute was determined and the counts of the two samples were compared. As a rule the ratio of radioactive content of the bone under investigation in relation to normal bone was approximately 1 : 1; but variations from 1 : 3 to 3 : 1 were accepted as evidence of a normal blood supply.

Results of investigation—Table I summarises the observations in a series of patients investigated by this method. It is not suggested that these are more than preliminary findings. It is of course possible that patients who do not yet show clinical evidence of avascular

FIG. 3

FIG. 4

Case 3. M. C. Radiographs twelve months and eighteen months after operation, in which the nail was at first placed perfectly in the middle of the head, leave no doubt that the head is avascular. But this radiographic proof was gained only after twelve months—which was too late. At the time of the first operation, when radioactive phosphorus was injected into the antecubital veins, the femoral head took up only one-tenth of the content of bones with a normal blood supply. Laboratory evidence of death of bone can be gained within hours instead of months or years.

necrosis of the femoral head may develop signs of it in future years. But it is noteworthy that, in this early stage, when a closely comparable content of the radioactive isotope was found in the femoral head and the trochanter (with ratios of 1 : 1, 3 : 2, 2 : 1 and 1 : 2) the fractures united quickly and there was no clinical or radiographic evidence of avascular necrosis; whereas when the ratio of isotope content between the femoral head and trochanter was 1 : 16 or 1 : 10, there was undoubted clinical evidence of avascular necrosis; and in case 11 where there was a ratio of 1 : 5 there was evidence of localised segmental necrosis.

Dangers and technical difficulties—The possibility of complications arising from the administration of radioactive phosphorus calls for careful consideration. Radioactive phosphorus may depress the activity of the haemopoietic system and indeed it is used in the

treatment of polycythaemia vera. But the dosage used to inhibit haemopoiesis (4 to 12 millicuries) is from twenty to sixty times greater than that used in this investigation (150 to 200 microcuries). We have seen no evidence of injury to the cellular components of the blood. The precise dosage of radioactive substances needed to stimulate carcinogenesis is unknown but we believe that in this investigation we have always been far below the critical level. Finally, although radioactive substances have been proved to cause mutation of genes in animals, and may no doubt have similar effect in humans, this can have little application to the aged patients we have studied.

Drilling of the femoral neck and head may damage the bone sufficiently to impair the efficiency of the Smith-Petersen nail. This risk can be reduced by careful technique, particularly if the sample is taken from the posterior and inferior quadrant of the neck and head. The greatest danger is that the trephine may damage the remaining vascular supply to the head. The most important vessels are the postero-superior retinacular arteries and the fovealar vessels. Any instrument driven into the head in the postero-superior quadrant, or into the fovealar region, may well injure the remaining patent vessels; but if these zones are avoided the investigation can be carried out with safety.

DISCUSSION

In an effort to reduce the amount of radioactive material to a minimum, dosages ranging from 287 to 100 microcuries of P^{32} were tried. If the readings are to be significant they must be considerably greater than the background count. A satisfactory reading was obtained in case 1 with a dose of 135 microcuries; but a dose of 120 microcuries in case 7 gave a reading that was too close to the background count to be of much value. Moreover, in case 1, four hours elapsed between injection of the isotope and removal of the sample and this long interval may be responsible for a relatively high reading in an avascular femoral head. There can be little doubt that 150 microcuries is the minimal dosage if local concentration in the bone tissues is to be examined adequately.

Time factors were also varied in an effort to determine the optimal interval between the injection of isotope and the removal of samples; the intervals varied from five minutes to four hours. In animal experiments it was found that the femoral head contained some radioactive material even when it was completely isolated from its attachments, and this has been attributed to absorption from the surrounding synovial fluid and blood. It was thought that the shorter the period of contact of the avascular fragment with the medium containing the isotope, the smaller would be the radioactive content of the avascular fragment. The interval was reduced to five minutes in one case, and to twenty-five minutes in another, but it seems probable that one hour is the optimal interval.

One of the disadvantages of this method of investigation is that only one small area of the femoral head is obtained for examination. It is known that segmental necrosis of the femoral head may occur and the method described may fail to demonstrate such regional infarction. It is unwise to remove more than one sample from the head because of the risk of damaging the blood vessels that remain. Moreover the technique requires radioactive material and expensive recording equipment. It is submitted, however, that laboratory evidence of death of the femoral head may be gained within a few hours; whereas clinical evidence, equally conclusive, is delayed until after many months.

It is hoped that the method will be investigated by others and that, if confirmed, it may become an accepted routine in the treatment of intracapsular fractures of the neck of the femur when the viability of the head is in doubt. It may even be possible to succeed in the attempts we have made to construct a small Geiger counter which can be inserted into the femoral head at the time of the original operation so that the surgeon will know at once whether the femoral head is dead or alive and will be able to modify his treatment accordingly.

SUMMARY

1. The pathology of avascular necrosis of bone and its relationship to the radiographic changes are considered briefly.
2. The inadequacy of radiographic examination in the early diagnosis of avascular necrosis is stressed.
3. Methods of early assessment of the residual vascularity of a bone mass are discussed.
4. Details of the principles, methods, and results of using radioactive phosphorus in the diagnosis of avascularity of bone are described.
5. The dangers and technical difficulties of using radioactive substances are discussed.
6. The possibility is envisaged that surgeons may soon be able to determine at the time of emergency operation whether the femoral head is dead or alive.

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FROM AN ATLAS OF GENERAL AFFECTIONS OF THE SKELETON

13. MYOSITIS OSSIFICANS PROGRESSIVA

Synonyms—Fibrositis Ossificans Progressiva

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This congenital affection is characterised by the formation of columns of bone in the soft tissues with progressive limitation of movement. It is usually associated with microdactyly. According to Vastine *et al.* (1948), it was von Dusch who named the condition myositis ossificans progressiva in 1868, though cases had been described many years before. This title is unfortunate because the primary change is in the connective tissues, fasciae and tendons, the muscle fibres being affected only secondarily; and moreover the changes are not of an inflammatory type. The condition was reviewed by Rosenstirn (1918) who collected 120 cases from the literature; in a few of these he rightly questioned the diagnosis, and he suggested that " fibro-cellulitis ossificans progressiva " was a more accurate title. The subject was reviewed by Nutt in 1923 and he added fourteen more cases from the literature together with one of his own. It was also reviewed by Mair in 1932. Other titles that have been suggested are " fibrositis ossificans progressiva " (Greig 1931) and " hyperplasia fascialis ossificans progressiva " (Goto 1912, reported by Rosenstirn).

Hereditary and familial influences—There is little evidence of hereditary or familial influence. Sympson (1886) reported a father and son with digital deformity but only the son developed myositis. Drago (1919) reported a patient whose mother had microdactyly. Burton-Fanning (1901) published the case of a father and son, both of whom had myositis ossificans. Gaster (1905) reported the affection in a grandfather, father and three sons—five cases in three generations. It has also occurred in twins, both of whom developed myositis (Vastine *et al.* 1948).

Sex—Both sexes are affected, males more often than females in the proportion of approximately three to two.

Age—It is obvious that microdactyly arises in foetal life, but the other manifestations usually develop in childhood before the age of ten years. In about 16 per cent. of cases the early signs were noted in the first year of life; and, in some, striking changes in the muscles have been observed so soon after birth that they must have begun in foetal life (Hutchinson 1860, Rosenstirn 1918, Mair 1932). Only occasionally is the onset delayed until adolescence. Mair (1932) found only two records of cases in which the first symptoms appeared after the age of twenty years (Frejka 1929, Hirsch and Löw-Beer 1929).

Etiology—Maldevelopment of the great toe must begin in early foetal life, and the fault that is responsible for changes in the muscles, no matter how long their onset may be delayed, is also congenital. The cause of this mesodermal fault is unknown. No error in calcium metabolism has been proved. It has been suggested that the underlying cause may be similar to that which is responsible for local ossification after injury, the difference between the two conditions being only one of degree (Painter 1921); but study of the two types of case provides little support for this suggestion. The disorder has been reported in dogs and, in at least one instance, it was associated with microdactyly (Rosenstirn 1918).

Clinical signs—Severe crippling may supervene within a few years or it may be delayed for three or four decades. In a typical case localised swellings appear during infancy and childhood, usually in the region of the head or neck and, sooner or later, in the trunk. The swellings may be painful but quite often they are painless and not tender. As a rule they are small, lasting only a few days or weeks, then subsiding or even disappearing altogether, only to be succeeded by others. Injury may sometimes determine the site of a lesion and start the whole

process, but as a rule injury plays no part at all. Garrod (1907) studied a child during the second year of life and described two types of swelling: 1) swellings attached to the deep fascia, covered with normal and mobile skin, firm, elastic and not tender, with thin processes extending from some of them; 2) diffuse, ill-defined thickening of the soft parts with adherent skin, sometimes with local oedema, seen mostly in the lumbar and sacral regions. A swelling that occurred in the neck caused oedema of the arm and dilation of the veins; in less than three weeks it had almost disappeared and the head then moved freely. A lump might divide into two, each part being joined by diffuse swelling; and one lump was seen to divide on two separate occasions. In studying a boy aged four years, Mair (1932) found that the swellings might be hard from the beginning and thereafter persist, or they might be cyst-like, fluctuant, and blue-red in colour. Swellings of the fluctuant type sometimes resolved into firmer lumps or they disappeared altogether; apparently these were haematomata. A lump has been known to break down and discharge. They vary in size. In a child aged eighteen months a swelling as large as an apple appeared in the neck and disappeared within two months (Westman 1924). In another case there was a swelling the size of an egg which also disappeared. One patient, when four years of age, was said to have the appearance of being "contused all over" (Hamada 1936).

The swellings often cause stiffness and inconvenience, if not actual discomfort; their development may be associated with slight fever even when occurring several months or years after the onset of the disease. Usually the overlying skin is not congested. Even in the early stages there is limitation of movement of the head and neck, often with wry-neck deformity, or limited movement of one or both arms. If a lump subsides or disappears, freedom of movement may be restored. The masseter is affected in about one-fifth of the cases. Almost invariably the dorsal aspect of the trunk is involved and there may be involvement of the proximal parts of the limbs, particularly the upper limbs. Limitation of movement or complete fixation of the elbow by bone block is not unusual but there is seldom involvement of the limbs distal to the elbows or knees. Lumps have been reported over the sternum.

Sooner or later columns, irregular masses or plates of bone appear in the soft tissues. If a lump does not disappear completely bone may be expected to make its appearance within a period of from two to eight months. These bony columns seem to lie in the course of a muscle—for example, in the sternomastoid or in the latissimus dorsi or erector spinae; but bone may also be laid down in tendons, fasciae and ligaments. Sometimes bone is found in unexpected places where it is difficult to decide the tissue in which it has formed: for instance, there is sometimes a bar of bone passing almost horizontally outwards from a mass in the back of the trunk to be attached to the humerus near the insertion of the deltoid, far below the normal position of any muscle inserted into the humeral shaft. The column may be attached to a skeletal bone at one or both ends; or it may be entirely free. On the back, nodular columns of bone often stand out boldly, not uncommonly forming a V, with or without a third vertical column in the midline; and in such cases the latissimus dorsi and erector spinae muscles are believed to be the sites of the bone formation. The deltoid, biceps, brachialis anticus and adductor magnus may be affected, but with much less frequency. The sternohyoid, genio-hyoid and sterno-thyroid muscles have sometimes been affected. The skin has been known to ulcerate over a projecting mass of bone, as for example in the region of the tuber ischii. Ossification of a tendon near its attachment may produce a form of "exostosis." In the forearm and leg the interosseous membrane may be involved.

Certain muscles seem to be exempt, namely the muscles of the eye, face, tongue, diaphragm, heart, larynx, perineum and the sphincters (Mackinnon 1924, Grant 1919). Bone formation has seldom occurred in the skin or in the abdominal wall (Rosenstirn 1918).

Sooner or later the spine becomes stiff with or without kyphosis or scoliosis. The whole spine, including the occipito-atlantal joint, may be completely rigid. The costo-vertebral

joints are stiffened and the chest becomes immobile. As a rule the patient is thin and wasted, and in the worst cases he is bedridden. Involvement of the masseter may interfere seriously with feeding and it may even be impossible to open the mouth. The masseter was involved at the early age of three weeks in a child who survived only six months (King 1854). The temporal and frontalis muscles have been affected (Morian 1899). Resistance to general infections is lowered and intercurrent disease is common. Nevertheless some patients have lived to an advanced age.

In the Hunterian collection of the Royal College of Surgeons of England there is the skeleton of a man of thirty-nine years, a full report of which has been studied by courtesy of Dr L. W. Proger. This specimen shows clearly that bone formation is not confined to the muscles nor even to their immediate vicinity (Fig. 11). In the skull many small outgrowths of bone are seen at various sites, including the supra-orbital ridge and the alveolar process of the superior maxilla; there is extensive ankylosis of the lateral articulations of the spine and most of the costo-vertebral joints; some neural arches are fused and, at certain levels, the supraspinous ligaments are ossified. Attached to the back of the left ilium is a perforated shell of bone which bulges outwards as if it had been formed in the subcutaneous tissue of the buttock—certainly not in the gluteus maximus. Passing from the angle of the left scapula to the humerus is a bar of bone which lies so low and so horizontal that it could have no possible connection with the teres major muscle. The carpal and tarsal ligaments are ossified. This skeleton, and two others similarly affected, are described by Stonham (1892).

Microdactyly was first recorded by Helferich (1879) and it is of diagnostic importance, particularly in the early stages before heterotopic bone has formed. The great toes are affected in about three-quarters of all cases. Hallux valgus is common and there may be a scar over the metatarsal head. Reduction in length of the thumb is less frequent; it occurs in less than half the cases. Other digits are affected exceptionally. In two cases all the fingers were reduced in length.

Other changes—In at least two cases the femoral necks were thickened (Rocher *et* Mathey-Cornat 1933, Griffith 1949). Mental and sexual development are normal. There may be some degree of infantilism, presumably secondary, but this is exceptional.

Blood chemistry—No constant abnormalities have been found. In the few cases in which blood phosphatase has been estimated it was within normal limits.

Radiographic appearances—The density of the extra-skeletal bone varies considerably: it may be less dense and less defined than the normal skeleton; or on the other hand it may be more dense, the skeleton as a whole being osteoporotic in consequence of the sererely restricted activity. Exostotic projections or subperiosteal thickenings on the shaft of a bone may be seen in addition to columns of bone in the soft tissues. In an advanced case there may be fusion of vertebrae. In one there was such extensive formation of bone in the quadriceps muscle as to suggest that there were two femoral shafts; and in another there was a continuous sheet of bone from the quadriceps to the tibia completely fixing the knee (Mair 1932).

Microdactyly is associated with reduced length of the phalanges of the great toe and only exceptionally with a short metatarsal bone; there is complete or incomplete suppression of the proximal phalanx which may be reduced to a wedge-shaped fragment. It is said that the phalanges are often fused but the evidence of this is not convincing. The first metatarsal may actually be increased in length by fusion of part of the proximal phalanx, thus forming a rounded end to the bone quite unlike the normal head. A similar shaping of the head may also be seen when the bone is shorter than normal. In the thumb, all three bones may be short, or there may be shortening only of the phalanges. In a case reported by Burrows (1933) the metacarpal was short and the epiphysis of the proximal phalanx was wedge-shaped. Spurs on the back of the os calcis or in front of its tuberosities have been reported. The formation of an " exostosis " on the phalanx of a finger has been described in two children (Rolleston 1901, Herringham 1898).

Progress—The condition usually becomes progressively worse, but the rate of progress varies. Intermissions are not uncommon and sometimes there may be arrest for several years. The time elapsing between the onset of the first symptom and final crippling of the patient may vary from less than ten years to as long as forty years. No treatment is known to arrest the progress of the disease although the possibilities of radiotherapy have not perhaps been fully explored. Operative excision of a bony column is very uncertain in its results; it may not improve the mobility of the joint and moreover bone is likely to reform.

Pathology—There seems no doubt that the primary change occurs in the connective tissue and not in the muscle fibres which are affected secondarily. Intercellular haemorrhage is succeeded by proliferation of embryonic tissue, particularly around the vessels and between the muscle fibres, together with the formation of adult connective tissue, cartilage and bone. These changes are accompanied by fatty, waxy and granular degeneration of muscle fibres and proliferation of the sarcolemma cells (Grant 1919). The new bone is metaplastic and does not depend in any way on the osteoblasts in the adjacent skeleton; it may be associated with the formation of cartilage, and the bone may be hard or soft, but microscopic and chemical examinations have revealed no differences from normal bone.

Diagnosis—Before a case has progressed to the formation of bone the diagnosis may be difficult; but the co-existence of microdactyly should settle any doubts. Myositis fibrosa, a very uncommon condition, is no longer universally regarded as a separate affection. It is noteworthy that microdactyly has been found in some cases reported as myositis fibrosa; but those who believe that the two conditions are distinct point out that myositis fibrosa is commoner in girls and in older patients, that it more often occurs in the lower limbs, and that it is accompanied by pain—even severe pain—much more frequently than myositis ossificans. Myositis fibrosa is said to attack the muscles of respiration and the laryngeal muscles and to run a more rapid course, even to a fatal termination (Mair 1932). The muscles have been described as feeling like a sandbag; and the overlying skin may be erysipeloid in appearance.

In calcinosis universalis, calcareous deposits may occur in the skin and subcutaneous tissues as well as in muscles and fasciae. Radiographically they are seen as granular and fragmentary opacities, distinct from the shadows cast by the bony skeleton. The same is true of the opacities seen when dermato-myositis results in calcification. In calcinosis the deposits may be absorbed; whereas in myositis ossificans progressiva, when bone is once formed it never disappears.

Dermato-myositis affects the extremities and only later the trunk. There may be fever and sweating, and the spleen is enlarged. The diaphragm, intercostal muscles and palate are affected. With intermissions, the course extends over a period of eighteen to twenty-four months, but not longer. Nevertheless the two affections, dermato-myositis and myositis ossificans, do seem to be closely related.

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CASE 1—MYOSITIS OSSIFICANS PROGRESSIVA

(Figs. 1 to 5.) Female, aged seven years. Extra-skeletal ossification first noticed when she was two and a half years old. Had been treated by prolonged recumbency for "glands." One of family of eight: others normal. On admission—mild kyphotic curve; dorsal and lumbar regions of spine completely rigid. Some movement in cervical spine. Erector spinae large and hard. Hard column in left latissimus dorsi; another mass in the right lumbar region. Bridge of bone in right pectoral muscles with bony protuberance fixed to the sternum. Upper limbs normal but thumbs rather short. Suspicious firmness of left calf (with doubtful shadow in radiograph). Reflexes normal. Bilateral equinus. Great toes small and dorsiflexed; first metatarso-phalangeal joints prominent; bilateral hallux valgus. Radiographs showed ectopic bone in the dorso-lumbar region on both sides, in the left cervico-dorsal muscles and in the right pectoral. First metatarsals abnormal: proximal phalances of great toes absent (possibly fused to metatarsals).

FIG. 1

Case 1—Photograph shows the swellings and deformity of the back. There is a vertical column of bone to the left of the mid-line in the cervico-dorsal region.

Tendo achillis lengthened on both sides. The opportunity was taken of removing the bar of bone from the right pectoral muscle; the mass consisted of a gelatinous lump containing bone; and this resulted in definite improvement in the mobility of the limb. Report from the mother thirteen years later: "She is still deformed; the shoulders and spine, and the muscles of the right hip are ossified. She can, however, walk quite well and she leads a normal life but cannot stoop to put on her shoes. She suffers no pain and is always cheerful and bright." Although the condition has progressed, extension of the ectopic ossification appears to have been slow.

FIG. 2

Case 1—Radiograph shows ectopic bone in the left postero-lateral tissues of the neck.

FIG. 3

Case 1—Microdactyly. First metatarsals appear to be lengthened by fusion with the proximal phalanges.

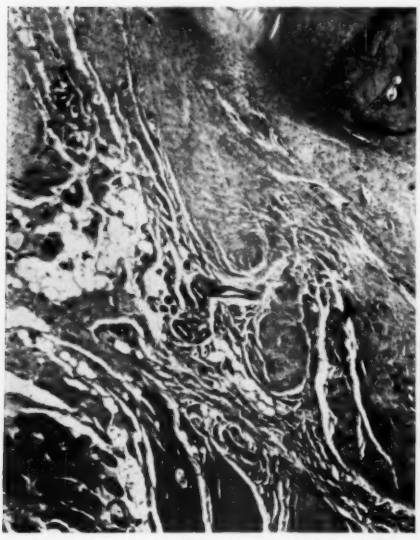

FIG. 4

FIG. 5

Case 1—Histological sections of the mass removed from the right pectoral region. Note in Figure 4 the degenerating muscle fibres (left bottom), newly formed bone and cartilage (right top), and intervening fibrous tissue. Figure 5 shows dense fibrous tissue merging below into cartilage and bone (×24).

CASE 2—MYOSITIS OSSIFICANS PROGRESSIVA

(Figs 6 to 10.) Male, aged sixteen years. No abnormality noticed at birth. At four months a swelling appeared on the scalp: this disappeared completely. At two years a swelling appeared on the front of the neck: aspiration yielded blood only. During the next five years similar swellings appeared in various parts of the back. Sometimes they followed trauma; and they gave the impression of moving from place to place. Some disappeared completely, but others left residual induration and stiffness. The swellings were not painful or tender. By the age of seven years the spine was completely rigid and movements of the arms were limited. Bone was removed from the right latissimus dorsi without benefit. Further swellings appeared but progress was generally slow, except for increasing limitation of movement of the mandible since the age of eleven years. Youngest of family of ten. No other member of family affected with myositis or microdactyly.

On admission spine rigid except for some movement in the cervical and upper dorsal regions. Chest expansion one inch. Bony plaques found at back of neck and in the dorsal and lumbar regions, especially in the latissimus dorsi and trapezius, left masseter, left sternomastoid (fused to clavicle) and right pronator quadratus. Outgrowths of bone from the lesser trochanters and adductor tubercles of the femora (very similar to exostoses in diaphysial aclasis). Plantar fascia involved. Microdactyly of big toes and thumbs. Deformity of great toes similar to that seen in Case 1. Biochemical examinations of blood revealed nothing of importance. (Under the late R. C. Elmslie.)

FIG. 6

Case 2—The hands show microdactyly of the thumbs with deformity of the epiphyses of the proximal phalanges.

FIG. 7

FIG. 8

Case 2—Figure 7 is a photograph showing the columns and plaques of bone in the back. Radiograph of the dorso-lumbar region shows irregular columns of bone on both sides of the spine (Fig. 8).

FIG. 9

FIG. 10

Case 2—Lateral radiograph of the cervical spine (Fig. 9) shows a branched column of ectopic bone part of which involves the sternomastoid. In Figure 10 it is seen that there is a small but well-defined calcaneal spur.

CASE 3—MYOSITIS OSSIFICANS PROGRESSIVA

(Fig. 11.) Male, aged thirty-nine years. Details of this patient, whose skeleton is preserved in the Hunterian collection of the Royal College of Surgeons of England, have been given earlier in this text (page 110). This specimen shows that bone formation is not confined to the muscles nor even to their immediate vicinity.

FIG. 11

Case 3—Drawing of skeleton (37941) in the Museum of the Royal College of Surgeons of England (after Stonham 1892).

CASE 4—MYOSITIS OSSIFICANS PROGRESSIVA

(Fig. 12.) Male, aged sixty-one years at death. Limitation of head movements were noted in infancy. From age of eighteen years disability was serious, and stiffness involved all four limbs. Report on the skeleton of this case in the Museum of Trinity College, Dublin, was published by Bennett in the Dublin Journal of Medical Science (1872).

FIG. 12

Case 4—Drawing of skeleton in the Museum of Trinity College, Dublin, showing very extensive extra-skeletal ossification (after Stonham 1892).

FROM AN ATLAS OF GENERAL AFFECTIONS OF THE SKELETON

14. OSTEOPATHIA STRIATA

H. A. Thomas Fairbank, London, England

This very unusual affection is characterised by striation of the skeleton and particularly of the metaphyses of long bones. In 1924 Voorhoeve published three case reports, a father and two children, in which radiographs showed striation of the metaphyses with other minor changes in the bones which had not been described before. Shortly afterwards, this author published a report of the clinical findings in a boy aged twelve years with predominantly unilateral changes in which striation was a prominent feature (Fairbank 1925) and Dr Voorhoeve agreed that the case was similar to those he had described. Striation of the bones was also a striking feature in an unpublished case brought to my notice by Dr Grace Batten, but it differed in many respects from those mentioned above and will be considered separately, with a similar case published by Uehlinger (1941).

In 1935 the author suggested osteopathia striata as a title for this obscure condition. Two rather similar cases, a brother and sister, were published by Lindbom (1942) under the title of striated osteopoikilosis (Voorhoeve) but they are exceptional in many ways, being neither quite like Voorhoeve's cases nor like osteopoikilosis. Lindbom believed that disseminated dermato-fibrosis in his two cases reinforced the concept that the striation was related to osteopoikilosis.

Hereditary and familial influences were evident only in Voorhoeve's original three cases. *Sex*—Three of the four cases were males. *Age*—Three of the cases were young, their ages being ten, twelve and fourteen years respectively: the fourth was the father of two of these children. *Etiology*—The cause is unknown: the author considers that it is the result of a congenital developmental error. Voorhoeve suggested that the striated bones he had described were related to dyschondroplasia and osteopoikilosis, the three disorders being variants of the same fundamental error, with the first forming a link between the other two, but this writer hesitates to accept such a view, particularly with regard to osteopoikilosis.

Clinical features—There appear to be no symptoms definitely referable to the bone dysplasia. Vague recurrent joint pains, with or without a little swelling, were complained of in the hip and knee joints of one patient and in the shoulder joint of another. The author's patient had suffered rheumatic fever affecting his heart, and in this unilateral case an abnormal gait and " awkwardness " had attracted the attention of the parents to the affected limb for some years and for this reason radiographic examination was made. The limb was longer and thinner than on the opposite side, but the upper limbs were of equal length. Otherwise there were no abnormal physical signs. *Blood examination*—Nothing of importance was discovered.

Radiological examination—The outstanding feature is striation affecting in varying degree all bones with the exception of the skull and clavicles. In the long bones the striation affects principally the metaphyses: the dense lines run parallel to the long axis of the bones and can be traced for a considerable distance into the shafts. The thickness of the striations varies but most of them are fine and linear. Between the lines the bones may be porotic. Voorhoeve called attention to the appearance of both clear areas and dense spots in certain bones; and he pointed out that in some places one of the dense lines appeared to break through the cortex. The striation may or may not extend into the adjacent epiphysis. Sometimes the epiphyses are mottled with dense and clear spots. The clavicles are not affected. The hands are less affected than the rest of the skeleton. Striation is well seen in the tarsus and especially the calcaneus. The patella may be affected. In at least one of Voorhoeve's cases,

the boy of fourteen years, the ilia were striated with lines radiating towards the crests like the columns of cartilage in dyschondroplasia. In our unilateral case there was a dense patch in the ischium on the side on which the striation of the long bones was more obvious, and a few irregular dense spots in the opposite ischium, these features being even more marked in radiographs taken some years later. Usually the cortex of the bone is of normal thickness and density, and there is no distortion. Voorhoeve, however, called attention to the presence of exostoses in his cases; these were very small and were not found in the other case.

Pathology—So far, no pathological material has been available for investigation but it seems probable that microscopic examination would reveal only normal bone of varying density. Striation of the metaphyses, in our case at any rate, does not appear to have been the result of any epiphysial fault: early radiographs of the lower femoral and upper tibial metaphyses showed that the most recently formed bone, to a depth of half an inch, was less dense than that formed earlier; and that these clear bands were largely free from the dense striation visible in the adjacent parts of the shafts; whereas radiographs taken four years later showed no clear bands in these bones, and the striations extended through the metaphyses to the epiphysial lines. Thus, the dense lines had developed *after* the bone forming the clear bands had been ossified. The region of the knee joint was the only place where juxta-epiphysial clear bands were visible in the early films.

Diagnosis—In dyschondroplasia, the bone between the columns of unossified cartilage often gives rise to a striated appearance but this is never seen with such regularity in every major metaphyses as in osteopathia striata. Moreover, in osteopathia striata the long bones of the hand and foot are less affected than the major long bones; whereas in dyschondroplasia the hands, and to a lesser extent the feet, are the chief seats of changes which could never be described as striation. Reference has already been made to the fan-like arrangement of striation which may be seen in the ilia in both these disorders.

The few dense spots seen in these cases are a little suggestive of those seen in osteopoikilosis; but in typical cases of osteopoikilosis certain parts of the skeleton, particularly the epiphyses, are closely peppered with dense spots. It is true that the spots in osteopoikilosis may be prolonged in some places into streaks but these are much shorter and much less regular than the dense lines seen in osteopathia striata.

Striation may be seen occasionally in one or two long bones in several other conditions but it is never distributed widely throughout the skeleton as in this affection. In melorheostosis dense streaking may be seen, but only to a very limited extent and only in one or two bones, while the character and limited distribution of the other changes are usually typical. In diffuse fibrosis of bone (polyostotic fibrous dysplasia), patches of increased density ending in two or three broad streaks may be seen in the radiographs but only in one or two bones.

The later films of the knee joint on the more affected side in our case showed some enlargement of the femoral and tibial shafts (enlargement of the fibula was noted in the earlier films), and the radiographic picture had become a little suggestive of that seen in diffuse fibrosis. The possibility that the affection in our case may not be identical with that responsible for Voorhoeve's cases cannot be entirely discarded. Similar increase of density, ending in streaks, may be seen in one or two long bones in neurofibromatosis; but this should be recognised without difficulty by other features. We have seen striation in the region of the knee joint in an atypical case of osteopetrosis. In Paget's disease an appearance worthy of the name of striation is exceptional: but it may be quite marked in the os calcis at early stages of the disease.

GENERALISED HYPEROSTOSIS WITH PACHYDERMIA

In 1941 Uehlinger published the report of a case of "hyperostosis generalisata mit pachydermie" affecting chiefly the long bones, with coarse striation of a considerable part of the skeleton. Dr Grace Batten's case, referred to above, appears to be identical except

that there was no pachydermia. Uehlinger referred to a number of other cases, some published before the discovery of X-rays, which he believed to be similar to the one he described. A familial tendency was apparent in many of them; and skin changes, affecting particularly the distal segments of the limbs, were present in some but not all. Other writers have linked these cases with pulmonary hypertrophic osteoarthropathy (for example, Freund 1938, despite the absence of changes in the chest and the marked differences in the radiographic appearances) but Uehlinger did not accept this view. Among the cases published with radiographs we have failed to find a single case that was strictly comparable with the patient reported by Uehlinger: in none was striation an outstanding feature. Uehlinger's patient was a farm worker who died at the age of fifty-five years, the condition of the bones having been discovered incidentally at the age of forty-one years when a radiograph had been taken during the treatment of an infected toe. Difficulty in walking over rough ground, and undue fatigue, had been noticed for about one year. There was disproportionate length of the lower limbs; and both forearms and legs were noticeably stout, the skin being thick and leathery. The spine was very stiff, chest expansion was limited, and there was limitation of movement of several other joints. Later, the patient complained of constant pain in the bones, and in the abdomen, together with difficulty in micturition which was attributed to spinal compression. The contracture of the limbs increased and he became bedridden. There was bilateral cataract, and clubbing of the fingers, but no calcification in the kidneys or arteries. Little advance in the bone changes occurred during the last ten years of his life. After death, examination of the bones showed that the marrow was fatty and not fibrotic; the hyperostotic bone was mostly of the woven type. Dr Batten's case, also a male, was above the average in height; his legs showed no obvious thickening and there was no dermatitis.

The cause of the condition seen in these two cases is unknown. In the second case there was a history of long-standing semi-starvation and the physicians considered that he had probably suffered from protein deficiency over a period of years.

The radiographic changes in these cases are of two kinds: 1) coarse striation of cancellous bone; and 2) thickening of the cortices of long bones. The striation is much coarser than that seen in osteopathia striata, and it is seen particularly well in the metaphyses and epiphyses of the long bones, the vertebrae and the tarsus. The hyperostosis, which on the whole is more pronounced on the external than the internal surfaces of the cortices, is seen on the shafts of all long bones. The density of the new bone varies considerably. In the metacarpals, metatarsals, and to a lesser extent the phalanges, there is no more than increased thickness of the dense cortices. In the major long bones the new bone is more variable in density though on the whole it is less dense than normal cortical bone and shows an irregular, fluffy surface. Some of these thickened bones are irregularly honeycombed, the appearance being rather suggestive of Paget's disease. The hyperostosis of the long bones was more advanced and more universal in the patient reported by Uehlinger, possibly because he was twice the age of Dr Batten's patient. The skull, ribs and vertebral bodies were comparatively free from cortical changes. In Uehlinger's case there was fusion of the lateral articulations and ossification of the dorsal ligaments throughout most of the spine; the vertebral bodies showed well-marked vertical striation in both cases. The pituitary fossa appeared to be normal.

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CASE 5—OSTEOPATHIA STRIATA

(Figs. 13 to 17.) Male, first seen when twelve years of age. Always ran awkwardly: " something wrong " with right leg. At ten years developed rheumatic fever, which affected his heart: no definite arthritis at any time. Awkwardness of right leg more noticeable recently. Family history negative. On examination—no limp. Right thigh thinner than left; calves equal; right lower limb half an inch longer than left. Movement of all joints free. Heart: loud mitral murmur. Urine contained trace of albumin: no Bence-Jones albumose. Radiographs showed striation affecting particularly the right side of the pelvis, the right half of the sacrum, and the bones of the right lower limb. The bones of the right upper limb, including the glenoid and acromion, were also affected, but not to the extent seen in the lower limb. The bones of the right side were generally more translucent than those on the left, and this accentuated the striated appearance. There was a little mottling with dense spots in some of the epiphyses and in the cuboid. The shaft of the right fibula was thickened. The bones of the left upper and lower limbs were not entirely free from changes but these were much less marked than on the right side. There was one dense spot in the right capitate and some mottling of the right ischium. The skull showed nothing abnormal. Radiographs taken four years later showed even more marked striation, the bones on the right side still showing more advanced changes than on the left. Osteoporosis in the bones of the right side had practically disappeared. The right ischium showed an area of increased density: there were a few dense spots in the left ischium. At the age of twenty years there were no symptoms referable to the bone dysplasia.

FIG. 13

Case 5—Pelvis and hip joints at the age of twelve years, showing on the right side some osteoporosis and dense striation with mottling in the head of the femur, the ilium and the tuber ischii. On the left side the only abnormal feature is slight striation of the femur.

FIG. 14
Case 5—Knee joints at the age of twelve years. Striation of the shafts and epiphyses is more marked on the right side. Right fibula is thickened.

FIG. 15
Case 5—Knee joints at the age of sixteen years. There is striation of both femora and tibiae. The shaft of the right tibia is now slightly enlarged as well as the fibula.

FIG. 16

Case 5—Pelvis and femora at sixteen years, showing striation, more marked on the right side, and dense spots in the head of the right femur, the right ilium and in the left ischium. In the right ischium is a dense patch. Note that the osteoporosis on the right side is now much less obvious.

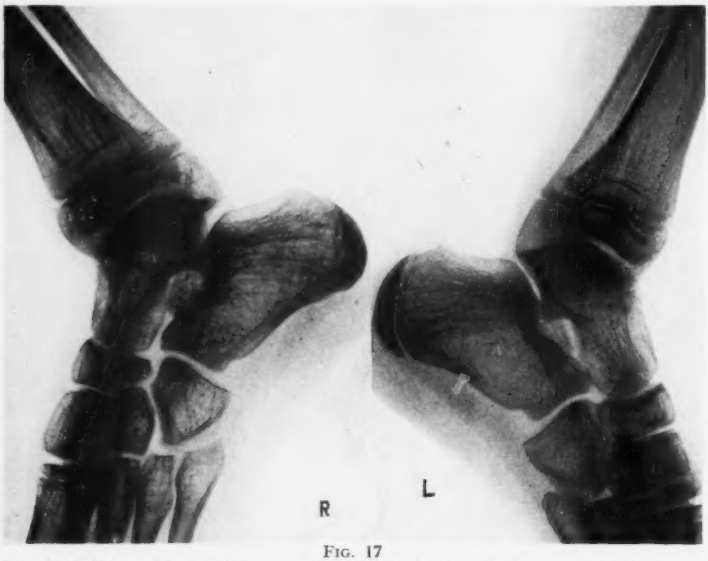

FIG. 17

Case 5—Ankles and feet atsixteen years. Striation is more obvious on the right, partly owing to the diminished density of the bones.

CASE 6—OSTEOPATHIA STRIATA

(Figs. 18 and 19.) Boy, aged fourteen years. For three years he had complained of recurrent attacks of pain and swelling of the left knee joint; the attacks lasted from a few days to a week and then cleared up completely. At four years had scarlatina followed by "rheumatism": recovery was complete. The blood and urine were normal. Radiographs showed marked striation of the metaphyses of all the long bones, the sacral wings, pelvis, patellae, calcanei, scapulae and the ribs near the costo-chondral junctions. There were also some clear areas and dense spots in the bones with slight enlargement of the metaphyses and a few small exostoses. His father, to a small extent, and his sister, showed similar changes (Dr Voorhoeve's case).

FIG. 18

Case 6—Knee joint showing marked striation with slight enlargement of the metaphyses, and a local projection resembling an exostosis on the inner side of both femur and tibia (after Voorhoeve).

FIG. 19

Case 6—Pelvis and upper femora showing striation which radiates in the iliac bones. The necks of the femora are rather thick and both show a tiny spur projecting downwards (after Voorhoeve).

CASE 7—HYPEROSTOSIS GENERALISATA with striation of the bones

(Figs. 20 to 26.) Male, aged twenty-eight years. Admitted to hospital with pneumonia. Had always been healthy but underfed. Investigations into his history showed that there had been prolonged deficiency in calcium, and vitamins A, B_1, C and D. Probably a protein deficiency over a period of many years. Repeatedly unemployed. His father and an uncle said to be of same build as himself. Other members of family normal. Patient is well above the average in height and is thin. Blood examination—negative. Radiographs showed coarse striation of the ends of most of the long bones, and of the vertebral bodies, tarsus, sacrum and, less obviously, the pelvis and ribs. The hands and feet show increased thickness, with uniform density, of the cortices of the minor long bones. There is a varying degree of hyperostosis of the major long bones, and the normal contrast between cortex and medulla is obscured. On the whole the surface of the thickened bones is fairly smooth. The left tibia shows fusiform enlargement posteriorly in the upper half due to thickening of the cortex. Except for slight increase in density the skull shows no definite change. (By courtesy of Dr G. Batten.)

FIG. 20

FIG. 21

Case 7—Note the lanky build of the patient (Fig. 20). Radiograph of the spine shows coarse vertical striation of the vertebral bodies (Fig. 21).

FIG. 22

FIG. 23

Case 7—Radiographs of the hands and foot show thickening of the cortex of the metacarpals and metatarsals (Fig. 22), striation of the tarsal bones and the ends of all the long bones. The density of the carpal bones is irregular.

FIG. 24

FIG. 25

FIG. 26

Case 7—The humerus shows altered texture and increase of density but no enlargement of shaft (Fig. 24). The forearm shows hyperostosis (Fig. 25). In the knee joint there is coarse striation and enlargement of metaphyses (Fig. 26).

Abraham Colles

Abraham Colles was responsible for much of the early scientific development of surgery in Ireland and was the leading Irish surgeon of his time; indeed he is regarded by many as the greatest of them all. His wider fame rests upon the classical descriptions he gave of certain anatomical structures and of a common fracture of the radius.

He was born at Millmount near Kilkenny on July 23, 1773, being descended from a Worcestershire family, some of whom had sat in Parliament. A branch of the family had settled in Ireland and one of its members was said to have been in medical practice in Kilkenny in the early eighteenth century; his descendent, William Colles, married Mary Anne Bates of Woodbrook, County Wexford, and Abraham was their son. The father, who managed the extensive quarries of black marble he had inherited, died when the boy was only six years old but the mother gave a good education to her young children and held their affection throughout a long life of eighty-nine years. They were sent to Kilkenny Grammar School where the headmaster was the Reverend John Ellison, sometime Fellow of Trinity College, Dublin, which college Abraham, and his brother William, entered in 1790. At the same time Abraham was apprenticed for five years to Philip Woodroffe, resident surgeon at Steevens' Hospital. Early in 1795 he took the degree of Bachelor of Arts, and later the same year was granted a licence to practice by the College of Surgeons. Whilst at Trinity he wrote a paper on "Remarks on the Condition of Political Satire" which he was advised to publish by Edmund Burke. Having received his diploma he proceeded to the medical school of Edinburgh University where, after two years of most assiduous work and frugal living, he gained the degree of Doctor of Medicine. From Edinburgh he journeyed to London, walking the whole distance of 400 miles. He attended some of its hospitals and at Guy's came into contact with Astley Cooper, whom he assisted in making the dissections which were to illustrate Cooper's monograph on hernia.

Colles returned to Dublin towards the end of the year 1797 and became attached to the Sick Dispensary in Meath Street, a Charity which had been established a few years before by the Society of Friends. The duties included home visiting in the slums of the city. He had not to wait long before receiving a hospital appointment but meanwhile this experience of medical practice among the sick poor, and acquaintance with their environment, was of great value before embarking upon the surgical career for which he was trained. On July 26, 1799, he was elected resident surgeon at Steevens' Hospital in succession to his former chief, Philip Woodroffe. At this same hospital he had served his apprenticeship and, having broadened his experience at other British schools, in Edinburgh and in London, and returned home proud of the friendship of Astley Cooper, it was at this hospital that he was destined to spend the rest of his surgical life. He was only twenty-six years of age and it was an important appointment, for he became administrative head of one of the leading hospitals of Ireland with complete charge of one-third of the surgical beds, and was also free to engage in private practice, to teach and to receive apprentices. Furthermore, on the attainment of this post he was elected a Member of the Royal College of Surgeons in Ireland, which at that time corresponded to the Fellowship of to-day. The College was in its early years and the reason for its foundation was much the same as that of the older English College. The Irish surgeons were determined, as their brethren over the water had been, to separate themselves from the

[We are grateful to the Chairman of Steevens' Hospital, Dublin, for permission to reproduce the portrait of Abraham Colles; and to Professor Rae, Registrar of the Royal College of Surgeons in Ireland, for his aid. We acknowledge with thanks the most efficient service and excellent photography of Independent Newspapers Ltd., Dublin, particularly since they have insisted that it should be offered freely to the Journal.—EDITOR.]

Abraham Colles
1773-1843

barbers, and this they partly accomplished by forming the Dublin Society of Surgeons on March 29, 1780. The next step was the education of surgeons and the regulation of the profession of surgery. In the University the teaching of medicine alone was undertaken; surgery was neglected; it still had the stigma of the barber. The Society therefore began to agitate and petition for a Royal Charter " dissolving the preposterous and disgraceful union of the surgeons of Dublin with the barbers and incorporating them separately and distinctly " into a Royal College. After a few years of opposition the Charter was granted on February 11, 1784. The next year three chairs were founded, one in anatomy including physiology, and the other two in surgery and midwifery. Thus the training of students began, but before admission to the College they had to pass a preliminary examination in Latin and Greek classics.

Colles worked with unflagging energy at Steevens' Hospital and soon became recognised as an able surgeon. He was a first-rate clinical observer and a dexterous and resourceful operator. He soon gained the respect and confidence of the Dublin surgeons, to such an extent that on January 4, 1802, when only twenty-nine years of age, he was elected President of the Royal College of Surgeons in Ireland. Two years later he was appointed Professor of Anatomy and Physiology, as well as one of the Professors of Surgery. The choice of Colles for these chairs was particularly happy. He had always been attracted to the study of anatomy, regarding it as the bedrock of surgery. He affirmed that in the training of students anatomy, in its application to surgery, should be the constant theme of the teacher. The anatomists of the Renaissance dissected and taught one system at a time—the muscles, the nerves, the blood vessels, the viscera, each separately without reference to each other; and this tradition of teaching by systems persisted until the beginning of the nineteenth century. James Macartney, Professor of Anatomy at Trinity College Dublin, who had been trained at St Bartholomew's Hospital and at the great Windmill Street School of Anatomy, appears to have been the first in the British Isles to teach topographical anatomy with emphasis on the relation of the structures of a part to each other. Colles adopted this new method of instruction and at every opportunity stressed " the practical application of anatomical researches to surgical uses." In this way he reorganised the teaching of anatomy at the College and succeeded in arousing and maintaining the interest of students by regional dissections, so that they made more " rapid advances in useful knowledge " than by way of their previous study of uncorrelated systems. Furthermore, he was the first to produce a work on this new topographical approach entitled *A Treatise on Surgical Anatomy* which was published in 1811. The book was reprinted in America in 1820 and again in 1831.

By his zealous devotion to dissecting and lecturing Colles enhanced the reputation of the College. At the same time his hospital work remained unabated, but in 1813 he resigned the appointment of resident surgeon and was promoted to the visiting staff as assistant surgeon. In 1811 he tied the first stage of the right subclavian artery for a large axillary aneurism, Thomas Ramsden of St Bartholomew's Hospital having tied the third stage of the artery for a similar condition two years previously. Each patient survived only a week because of sepsis. In his published paper describing the anatomy and details of the operation, Colles concludes: " Although this operation has not yet proved ultimately successful, I think we should not despair. The history of surgery furnishes parallel instances of operation, now generally adopted, which, in the first few trials, failed of success."

On the Distortion termed Varus or Club Foot was the title of a paper he contributed to the Dublin Hospital Reports of 1818. Two dissections of varus feet were described in detail, one of a child of five years and another of a youth of eighteen. Although he noted that " the os scaphoides was drawn inwardly from the normal head of the astragalus " yet he concluded that the oblique position of the tarsal joint, and the altered form of the astragalus were the primary causes of the distortion; from which it would appear that he either did not accept or did not fully appreciate the well-known dictum of Scarpa in his summary of the anatomy

of varus which was that " none of the tarsal bones is actually dislocated; but in addition to the state of extension of the ankle joint, they undergo rotation on their axes, and the astragalus suffers less alteration of position than any of the tarsal bones." Colles cured many of these deformed feet by treating them with a club foot shoe of his own device. The shoe had a resistent sole of tin, covered with leather, laced down the middle and open at the toes. A broad strap in front of the ankle held the heel in the angle between upper and sole. A detachable angular side splint, slotted into the sole, extended along the inner side of the foot and up the inner side of the leg. Another splint, also slotted into the sole, continued along the outer side of the leg only. The splint, of which an illustration was given, corrected the equinus deformity and promoted eversion of the foot. It was applied a few weeks after birth and was continued for three months or more.

Colles was also interested in spinal disease. He adopted the teaching of Pott in his condemnation of steel stays and " other pieces of machinery " but was less convinced about the efficacy of applying caustic to each side of the gibbus. He displayed a remarkable prophetic insight with regard to the value of rest and the open air by saying: " it is absolutely necessary that the patient should be kept in the horizontal position, and this not merely for two or three months, but for a year or even two. But the caustic issues and position alone will not cure the disease of themselves; the general health, the tone of the constitution must be improved by country air, proper diet and so on; it will not be enough to send your patients to the country, if they are left shut up in a room; they must be brought out into the open air, but of course in a cot, for they are not to quit the horizontal position."

Because of the work of Colles on the anatomy of the perineum and on the common fracture of the radius his name is familiar to every student of medicine.

Colles' fascia—In the *Treatise on Surgical Anatomy* of 1811 Colles dealt with the anatomy of the perineum and, in particular, drew attention to the middle fascia of the urogenital triangle, the attachments of which served to confine within strict limits extravasation of urine from a ruptured urethra. He described this structure as follows: " Now proceed to dissect the perineum. Raise the skin of the perineum, extending the dissection beyond the tubera ischii to the thighs. This exposes to view a strong fascia, which, on dissection, will be found to cover the entire of the perineum, and to blend itself with the structures of the scrotum. This fascia, although on a superficial view it appears continuous with the fascia of the muscles of the thigh, will yet be found, on closer examination, to attach itself very firmly to the rami of the ischium and pubis. The texture and connexions of this fascia will serve to explain many of those phenomena attendant on the effusion of urine into the perineum, by rupture or ulceration of the posterior part of the canal of the urethra.

" First, then, you will find that this fluid, when so effused, although it forms a tumour in perineo, rarely terminates by suppuration and ulceration in this spot; being here resisted by the dense and unyielding texture of the fascia, diffusion laterally towards the thighs is prevented by the close attachment of this fascia to the rami of the pubis and ischium; while its progress forwards is favoured by a quantity of cellular substance, interposed between the surface of the perineal muscles and this fascia."

Colles' ligament is the name sometimes given to the small triangular fascia which springs from the pubic crest and ilio-pectineal line and passes upwards and inwards towards the linea alba under cover of the internal pillar of the external abdominal ring. This ligament is also described in his book on Surgical Anatomy.

Colles' fracture—At Stephen's Green on February 21, 1814, Colles wrote his classical paper, *On Fracture of the Carpal Extremity of the Radius*, which appeared in the Edinburgh Medical and Surgical Journal in April of that year. It was a comparatively short paper but in its accuracy, clarity and conciseness, it was admirable. It is an outstanding descriptive fragment of clinical surgery the reading of which conveys a feeling of finality in the presentation of the signs of fracture and deformity. The passage of time has altered only

the treatment of this injury and not more than twenty years have passed since a satisfying technique has emerged. Colles was established as a great clinical surgeon by this paper. At the time he wrote it, he had not been able to verify his observations by dissection and he had not the advantage of X-rays. There is scarcely a reference to this common injury in the literature before 1814. Those who were aware of it believed that it was a dislocation of the carpus. Colles dissented from this view: " The injury to which I wish to direct the attention of surgeons, has not, as far as I know, been described by any author; indeed, the form of the carpal extremity of the radius would rather incline us to question its being liable to fracture. The absence of crepitus and of other common symptoms of fracture, together with the swelling which instantly arises in this, as in other injuries of the wrist, render the difficulty of ascertaining the real nature of the case very considerable.

" This fracture takes place at about an inch and a half above the carpal extremity of the radius, and exhibits the following appearances.

" The posterior surface of the limb presents a considerable deformity; for a depression is seen in the forearm, about an inch and a half above the end of this bone, while a considerable swelling occupies the wrist and the metacarpus. Indeed the carpus and base of the metacarpus appear to be thrown backward so much, as on first view to excite a suspicion that the carpus has been dislocated forward.

" On viewing the anterior surface of the limb, we observe a considerable fulness, as if caused by the flexor tendons being thrown forwards. The fulness extends upwards to about one-third of the length of the fore-arm, and terminates below at the upper edge of the annular ligament of the wrist. The extremity of the ulna is seen projecting towards the palm and inner edge of the limb; the degree, however, in which this projection takes place, is different in different instances. . . . At last, after many unsuccessful trials, I hit upon the following simple method of examination, by which I was enabled to ascertain that the symptoms above enumerated actually arose from a fracture, seated about an inch and a half above the carpal extremity of the radius.

" Let the surgeon apply the fingers of one hand to the seat of the suspected fracture, and, locking the other hand in that of the patient, make a moderate extension, until he observes the limb restored to its natural form. As soon as this is effected, let him move the patient's hand backward and forward; and he will, at every such attempt, be sensible of a yielding of the fractured ends of the bone, and this to such a degree as must remove all doubt from his mind."

Colles' Law—In 1837 Colles published a book entitled *Practical Observations on the Venereal Disease and on the Use of Mercury*. He strongly advocated the use of mercury in syphilis in opposition to a prevailing tendency amongst surgeons to employ less effective remedies. But in using it he maintained strict control of the patient and of the use of the drug, for his experience in clinics for venereal disease had taught him the dangers of mercurial poisoning. In a chapter dealing with syphilis in infants, he made an observation which later became known as Colles' Law: " One fact well deserving of our detention is this: that a child born of a mother who is without any obvious venereal symptoms and which, without being exposed to any infection subsequent to its birth, shows this disease when it is a few weeks old, this child will infect the most healthy nurse, whether she suckle it or merely handle and dress it; and yet this child is never known to infect its mother, even though she suckle it while it has venereal ulcers on the lips and tongue." He clearly observed the apparent immunity of the mother but could not have guessed that she already had the disease in a mild form. It was nearly seventy years later that the Spirochaeta pallida of Schaudinn was discovered and the serological test devised by Wassermann.

This work on venereal disease was his last important contribution. Failing health had compelled him to resign the professorship of surgery one year before his observation. He had already vacated the Chair of Anatomy in 1827 at a time when he was lecturing to over 250 students. He continued at Steevens' Hospital until 1841, where he had served as man and

boy for close upon half a century and had been Consulting Surgeon to the Rotunda Hospital since 1826. In 1830 he was elected for the second time President of the Royal College of Surgeons in Ireland, and nine years later was offered a baronetcy but declined the honour. He died on December 16, 1843, and " his funeral was attended by a huge concourse of medical men, students and friends."

For the last twenty years of his life he had the most lucrative surgical practice in Dublin and this in spite of the demands of his professorship and hospital duties. He lived during most of his life at 21 Stephen's Green, having married Sophia, daughter of the Rev. Jonathan Cope, Rector of Ahaseragh, County Galway. They had ten children; the eldest son, William, became Regius Professor of Surgery at Trinity College and was elected President of the Royal College of Surgeons in Ireland in 1863. Colles was an indefatigable worker all his life; he was often in his dissecting room before six o'clock in the morning, and at Steevens' Hospital at seven. As a lecturer he was always earnest, lively and sometimes humorous. A critical contemporary speaks of him as " without many books, and paying less attention to their contents, he is still the laborious, shrewd, observing, matter-of-fact and practical surgeon. As an operator he has many equals, and some superiors; but in advice, from long experience and a peculiar tact in discovering the hidden causes of disease, he has scarcely a rival." He was a close and accurate observer; nothing escaped him; yet he was cautious in interpreting what he observed, and this quality of mind often prevented him from speculative reasoning about the behaviour of disease. He made a substantial contribution to knowledge, added to which the " outstanding feature of his character was his strict honesty both in thought and deed, and he followed consistently the highest code of professional honour." And what he had to say was communicated in such a simple and easy style that the reading of his papers gives a peculiar pleasure even to-day.

On his retirement in 1836, the College presented an address to him which said " It is the unanimous feeling of the College that the exemplary and efficient manner in which you have filled this Chair for thirty-two years, has been a principal cause of the success and consequent high character of the School of Surgery in this country." No other surgeon of Ireland holds so secure a place in the history of British surgery. ARTHUR ROCYN JONES

I gratefully acknowledge the help kindly given me by Mr H. Osmond-Clarke, C.B.E., and Mr Terence McSweeney.

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PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

CANADA

ROYAL COLLEGE OF PHYSICIANS AND SURGEONS OF CANADA

We report with deep regret the sudden death of the president of the Royal College of Physicians and Surgeons of Canada. Dr Fulton Gillespie of Edmonton, after presiding at a meeting of the College in Toronto, died in the train on his way home. His loss is felt deeply by all those who knew him and recognised how great a part he was playing in the destinies of the Royal College of Canada. Messages of sympathy were sent from the President of the Royal College of Surgeons of England, and from the British Orthopaedic Association. The new president is Professor Sclater Lewis of Montreal and to him our best wishes are sent in support of his onerous duty.

Sir Reginald Watson-Jones, Arthur Sims Commonwealth Travelling Professor of Surgery, will be visiting the medical schools of Canada in February and March. In Montreal he will bring to the president of the Royal College of Physicians and Surgeons of Canada the greetings of the president and Council of the Royal College of Surgeons of England. He will be a guest-Professor in the University of Toronto, and will visit the medical schools of Vancouver, Edmonton, Winnipeg, Kingston, London Ontario, Quebec and Halifax.

CANADIAN ORTHOPAEDIC ASSOCIATION

Crest of the Canadian Orthopaedic Association

In the last British number of the Journal we reported that the incoming president of the Canadian Orthopaedic Association, Dr Alexander Gibson of Winnipeg, had designed a crest for the Association which had been adopted. We are now able to reproduce the crest. As Dr Gibson himself writes: "The significance of the design is that the maple leaf stands for English-speaking Canada, combined with the *fleur-de-lys* representing French-speaking Canada, the stalk of both emblems being in common. The Greek *orthe* means straight or correct; and *paideia* means education, or the bringing up of youth. The derivation is therefore using the same motto as that of the American Orthopaedic Association and of the American Academy of Orthopaedic Surgeons, but sufficiently distinctive to make this our own."

GREAT BRITAIN

UNIVERSITY OF LIVERPOOL

UNIVERSITY DEGREES AND COLLEGE DIPLOMAS—MASTER OF ORTHOPAEDIC SURGERY

So often is reference made in one phrase to the "art and science of medicine" that there may be danger of failing to recognise that art and science are not the same. Until recently the diploma of a College and the degree of a University have been more or less interchangeable. To a physician in Great Britain the M.R.C.P. and the M.D. have meant much the same thing—though most physicians have thought that they should gain both; and similarly, surgeons with the F.R.C.S. have felt under an obligation to square it with an M.S. Moreover this hunting for degrees and diplomas has been made worse by the fact that a diploma of one College was often not enough; students found themselves chasing from a primary fellowship in London, to a final fellowship in Edinburgh, to another fellowship in Australia, and then to a mastership in their own University.

The secondary problem of multiple fellowships is now almost solved by the interchangeability that is being achieved between the Royal Colleges of Surgeons in England, Scotland and Australasia, and perhaps, in due course, between all the Colleges of Surgeons in all parts of the English-speaking world. But the underlying problem remains. What is the relationship of a diploma in one of the Royal Colleges to a degree in one of the Universities? Are they the same? Are they interchangeable? Surely not.

We should distinguish the practical art that was measured by our forefathers in the Companies of Surgeons, and by us in the diplomas of the Royal Colleges, from the academic achievement that alone warrants the conferment of a University degree. The test by which to determine that a man is qualified to be a fellow of one of the Royal Colleges should be his practical and clinical ability: and the test by which to determine that he may hold the mastership of a University should be his knowledge of the literature, his capacity for research and ability to compose a thesis, and his intellectual and academic distinction. It might well be argued that the same holds good even of the bachelorships of medicine and surgery; and that the qualifying examinations to practise medicine and surgery should be the memberships of Royal Colleges, thus leaving all University degrees in medicine for a different, and in some respects, a higher mark of achievement.

In later issues of the Journal it is proposed to discuss these problems in more detail. Meanwhile let it be said that the Mastership in Orthopaedic Surgery of the University of Liverpool has gone far to achieve these ideals. This degree is certainly not the equivalent of an F.R.C.S. for the surgeon who proposes to limit himself to orthopaedics; and most assuredly it is not a " back-door approach to specialism." Indeed, none may now engage in study for this mastership unless he has already had suitable training, shown clinical ability, and gained the fellowship of one of the Royal Colleges of Surgeons. The preparation for the examination, training in search of the literature, practice in presenting and discussing academic problems, writing of theses, and the nature of the examination itself, leave no doubt that the award is made only when University distinction is warranted.

At a recent examination the internal examiners were Mr B. L. McFarland (Director of Orthopaedic Studies), Mr Norman Roberts, Mr Eric Wardle and Professor Sheehan; and the external examiners were Mr R. I. Stirling (Edinburgh) and Sir Reginald Watson-Jones (London). Of those postgraduates whose previous record and experience was such that they were selected from nearly fifty applicants to engage in study in the University for fifteen months, the sixteen who graduated successfully as Masters of Orthopaedic Surgery were:

Abdallah, M. A.	Egypt	McLean, P. M.	Canada
Akrawi, G. Y.	Iraq	Marks, K. L.	England
Allen, C. E. L.	South Africa	Milsom, H. B. C.	New Zealand
Day, F. G.	Canada	Rosenzweig, N.	South Africa
Iskander, R.	England	Royle, N. J.	Australia
Jones, E. A.	Canada	Scrase, W. H.	England
Law, W. B.	Australia	Townsend, R. G.	Canada
McGlynn, R. W.	Australia	Watts, A. W. J.	Australia

The Directors' Prize was awarded, on the joint recommendation of the external examiners and the Liverpool orthopaedic surgeons, to H. B. C. Milsom, Auckland, New Zealand.

ROYAL COLLEGE OF SURGEONS OF ENGLAND

Christmas dinner of the Residential College—The residential college for postgraduate students, which is within the precincts of the College itself, has been occupied fully by young surgeons from the British Empire and many other parts of the world since the day it was opened last year by Viscount Nuffield. The Christmas dinner was held on December 29. After taking cocktails with the president, the residents dined in the Council room with their guests, the president, Sir Cecil Wakeley; the past-president, Lord Webb-Johnson; the chairman of the postgraduate education committee, Sir Reginald Watson-Jones; the visitor for postgraduates, Sir Gordon Gordon-Taylor; and the warden and secretary of the residential college, Mr R. J. Last and Mr W. F. Davis. With the treasured plate of the College on the table, the portraits of great surgeons on the walls, the turkey carved at the board by the *chef*, the Christmas pudding (even if the brandy did refuse to light) and the champagne and cigars, the foundations were laid for an evening of good fellowship. The president gave the toasts of the King, and the President of the French Republic.

Dr G. Vourc'h (France), chevalier Legion d'Honneur, Croix de Guerre, M.C., proposed the toast *The Royal College of Surgeons of England*. He recalled that he first came to England ten years ago during the bitter years when this country stood alone. It was not by an accident that he found himself back again, now studying anaesthesia. He thanked the College for opening its doors and said that he was an interpreter for all foreign students when he acknowledged the welcome they were receiving from the College. In reply, the president expressed his appreciation that the health of the College had been proposed by a representative of France, and one with so very distinguished a military record. The influence of the College had indeed spread over the world and its future in postgraduate training was assured.

Dr J. A. S. Wilson (Canada) spoke of the changed atmosphere in the College; it was no longer an aloof examining body; it was a home where happiness abounded, except perhaps at examination times. Lord Webb-Johnson, in replying, said that by living in the College young surgeons had the opportunity of making contact with many of the leaders of surgery. If such a residential college had existed years ago, he himself

might have dined with Lister—and what a privilege that would have been. He gave a fascinating commentary on the history of the silver cups of John Hunter, Cheseldon and Erasmus Wilson, the Bland-Sutton plate, and the portraits in the Council room; and referred to the many historic associations of Lincoln's Inn Fields.

Dr G. N. Ranking (South Africa) said that it was with surprise and pleasure that young surgeons visiting this country found that the authors of well-known books were not just names but living men, engaged actively in helping postgraduate students. One of the foremost, with whose name the toast was coupled, was Sir Reginald Watson-Jones. In reply, Sir Reginald emphasized the value of the collegiate atmosphere rather than that of the lecture room alone. He suggested that one of the great human achievements in which surgeons should be trained was the art of writing and oratory; not only was cultivation of clear expression essential in order to deal successfully with patients, but by good writing and speech a surgeon might inspire other surgeons so that his work did not die with him.

Dr Peter G. Jones (Australia), proposing The Sister Colleges, said that the Royal Colleges of Surgeons in Edinburgh and Ireland had long-standing traditions whereas those of Canada and Australasia were more recent; they were more nearly daughter than sister colleges. Might Sir Gordon Gordon-Taylor be regarded as the father? The high esteem with which he was held in Australia was indicated by the name of the prize just instituted in that country—the Gordon-Taylor prize. In reply Sir Gordon recalled the many happy memories of his visits to America and Australia.

Dr Peter Williams (Australia) expressed appreciation for the amenities of the residential college. Dr J. B. M. Ewen (Scotland) proposed the health of the warden, and Mr R. J. Last replied.

Laming Evans Research Fellowship in Orthopaedic Surgery—In the first British number (1948, **30–B,** 205) mention was made of the Laming Evans bequest for research in orthopaedics by which the Royal College of Surgeons of England has established a Laming Evans Research Fellowship of the annual value of £600, renewable up to three years. The first award has been made to Miss Agnes Sleigh, who qualified in Aberdeen in 1945 and then held a number of resident appointments in England, a demonstratorship of anatomy at Charing Cross Hospital Medical School and an appointment at the country section of the Royal National Orthopaedic Hospital. She will continue to work there, under the guidance of Mr H. J. Seddon, Director of Studies in the Institute of Orthopaedics. It is perhaps fitting that the first holder of this research fellowship should work in the hospital which Laming Evans himself served for forty-three years.

Robert Jones Lecturer in the Royal College of Surgeons of England for 1950—Professor Philip D. Wilson of New York has been appointed Robert Jones Lecturer in the Royal College of Surgeons of England for 1950.

INSTITUTE OF ORTHOPAEDICS

ROYAL NATIONAL ORTHOPAEDIC HOSPITAL, LONDON

Open clinical conferences will be held at 8 p.m. on February 22, March 22, May 24, June 28, October 25 and November 22. Visitors will be welcomed. All the conferences will be at the Town Section of the Royal National Orthopaedic Hospital, Great Portland Street, except that of June 28, which will be held at the Country Section, Stanmore.

UNIVERSITY OF LIVERPOOL

Lady Jones Lecture—Professor S. L. Baker, Ph.D., professor of osteopathology in the University of Manchester, delivered the ninth Lady Jones Lecture in the Arts Theatre of the University of Liverpool. His subject was "Basic Reactions of Bone Tissue." He dealt with it in a manner which was as clear and concise as it was interesting and stimulating. Having described normal bone and the ways in which it can react, he then passed on to a vivid description of functional types of bone tissue varying with the arrangement of the fibres. On the one hand is the lamellar bone and on the other is the primitive type which he called woven bone. He then traced the history of observations on the absorption of bone and indicated his own views. He thought the term de-ossification, though less euphonious, was more accurate than decalcification. He expressed disbelief in "halisteresis" and "osteolysis" and believed that the deposition of calcium salts in a matrix is not reversible. The normal calcium intake and output and skeletal deposit were compared diagrammatically with certain abnormalities occurring in rickets and hyperthyroidism. The effect of stresses on bone including increased stress and decreased stress was also described and shearing stress received particular attention. The whole lecture was illustrated by the clearest and most satisfying lantern slides the writer has ever seen.

Hugh Owen Thomas Memorial Lecture—Sir Reginald Watson-Jones delivered the Hugh Owen Thomas Memorial Lecture at the Liverpool Medical Institution on Friday, November 11, 1949. He presented a coloured transparency prepared from a recently discovered portrait of Hugh Owen Thomas to the Hugh Owen Thomas and Robert Jones Memorial Library of the Institute.

The intervertebral disc—On Thursday, January 19, a discussion was held in the Liverpool Medical Institution under the presidency of Professor Charles Wells. "The Function of the Disc" was discussed by Mr W. J. Virgin (in a paper read by Mr Bryan McFarland), the "Conservative Treatment of Disc Lesions" was discussed by Mr E. N. Wardle and the "Operative Treatment of the Disc Lesion" by Mr A. Sutcliffe Kerr.

NUFFIELD ORTHOPAEDIC CENTRE
WINGFIELD-MORRIS ORTHOPAEDIC HOSPITAL, OXFORD

The Lecture Programme for the Hilary Term, 1950, includes a lecture on February 9 by Professor J. Trueta, on February 23 by Dr V. Smallpeice, and on March 9 by Mr J. C. Scott. On March 23 the lecture will be opened by Mr E. W. Somerville.

REGIONAL ORTHOPAEDIC CLINICAL MEETINGS
THE MANCHESTER HOSPITAL REGION

The orthopaedic surgeons of the Manchester Hospital Region held two clinical meetings during 1949. The first meeting was held at the Ethel Hedley Children's Orthopaedic Hospital, Windermere, on July 23, 1949, and was attended by some twenty-five surgeons and by a number of registrars. A dinner was held on the evening of July 22.

The clinical meeting began with a ward round conducted by Sir Harry Platt, and an interesting group of joint affections was shown; including 1) pseudo-coxalgias; 2) congenital dislocation of the hip, and 3) tuberculosis of the major joints. A buffet luncheon was served at the hospital, and the afternoon session consisted of short communications. *Mr E. S. Brentnall* presented radiographs of two interesting cases of Paget's disease with cystic changes. *Mr Sayle-Creer* described the operative approach to the temporo-mandibular joint by means of a modified J-shaped skin incision. *Dr John Fawcitt* showed radiographs of a case of osteitis of undeterminate origin, and also films of osteitis tuberculosa multiplex cystica. *Mr E. Flatow* showed films of a case of sarcoma of the tibia followed by a curious periostitis of the long bones. *Mr W. McKechnie* showed radiographs of a pathological fracture of the neck of the femur through an area of cystic change which had been treated by curettage and chip grafts. The meeting was of the opinion that it was a case of solitary bone cyst. *Mr I. D. Kitchin* presented films of a tumour in the region of the hip with massive soft tissue calcification. *Mr H. C. Cullen* related his experiences with curare in acute poliomyelitis, and stated that it was a useful contribution in the treatment of this condition. *Mr W. Winston* described a series of traumatic central dislocations of the hip over a follow-up period of five years. They showed a remarkable range of movement considering the intra-articular damage. *Mr D. A. Richmond* showed radiographs of a case of multiple spontaneous fracture of the spine not associated with changes in blood chemistry. He promised a further report at a later date. *Mr W. Lamont* showed films of a boy discovered to have a cystic lesion in the pubic ramus on the right side which was thought to be tuberculous in origin; it had responded satisfactorily to prolonged rest.

The second clinical meeting was held on November 25, 1949, at the Blackburn and East Lancashire Royal Infirmary. *Mr R. W. Agnew* opened the morning session by demonstrating four patients with recurrent dislocation of the patella treated by plication of the capsule and transference of half of the tibial tubercle to the medial side; three patients successfully treated for "snapping hip" by excision of a tight band of fascia over the trochanter, in one case with anterior transplant of the tensor fasciae femoris; and three cases of discoid external cartilage in children treated by excision. *Mr W. H. Power* presented a short paper on the conservative treatment of acute osteomyelitis. He pointed out the minimal bone changes and compared the conservative method with that of metaphysial drilling. The opinion of the meeting was divided on the most advantageous method. *Mr R. W. Agnew* and *Mr G. A. Macadie* demonstrated an atypical case of polyostotic fibrous dysplasia. The man presented a bizarre deformity with enlarged pitted skull, shepherd's crook deformity of both femora, generalised cystic changes and sclerosis throughout the skeleton. *Mr J. J. Jennings* showed two cases of fracture of the sternum with overriding of the fragments; one accompanied by fracture of the dorsal spine. A most enjoyable luncheon was served at the hospital.

Mr D. Ll. Griffiths opened the afternoon session with a demonstration of the articular surfaces of the knee joint showing gross destruction and having the appearance of a syphilitic knee; section, however, revealed that it was in fact tuberculosis. He showed a specimen of a rare case of actinomyosis of the spine, and radiographs of a curious intramedullary chondroma of the femur. He also showed a case of Paget's disease with pathological fracture of the neck into which a Smith-Petersen nail had been inserted. The pathological fracture had later been proved to be due to an early sarcoma. *Mr John Charnley* presented further observations on compression arthrodesis and demonstrated some interesting histological sections showing early union with bony trabeculae across the line of osteotomy. These specimens had been obtained by boring across the line of osteotomy at varying times after arthrodesis of the knee. He was undecided as to whether compression *per se* or fixation was the important factor in ensuring early union. *Mr R. S. Garden* demonstrated a novel method of dealing with subtrochanteric fractures of the femur where angulation could not be corrected. Patients were treated on a Thomas splint, the outer bar of which was cut and shortened, thus bringing the distal fragment in abduction and alignment. He presented radiographs of

a successful result in this method of treatment. *Mr I. D. Kitchin* presented a case of pathological fracture of the radius through a rarefied area which proved to be the first evidence of Paget's disease. *Mr Basil Haigh* presented a review of the results of subtrochanteric osteotomy in a series of patients treated at the Manchester Royal Infirmary. He divided the cases into two groups—those in which the osteotomy had been done for the relief of pain in osteoarthritis, and those in which the operation had been necessary subsequent on a fracture of the femoral neck. Despite the fact that the essential principles laid down by T. P. McMurray for this operation had not in the majority of cases been followed completely, the results over a five-year period had proved to be extraordinarily good; almost all the patients had been improved by the operation. A lively discussion followed. *Mr N. A. G. Covell* showed radiographs of an unusual case of fracture-dislocation of the carpus with dislocation of the os magnum. He had been unable to find a similar case described in the literature. Reduction had been obtained with difficulty and a useful range of movement was regained.

AGNES HUNT MEMORIAL VILLAGE FOR CRIPPLES

Representatives of cripple organisations and after-care committees from all parts of England and Wales gathered at Shrewsbury Castle on January 14 at an inaugural meeting for the Dame Agnes Hunt

Bust of Agnes Hunt whose memory is to be perpetuated by the building of a village settlement for cripples near the Robert Jones and Agnes Hunt Orthopaedic Hospital and the Derwen Cripples' Training College.

Memorial. It is proposed to build a village of bungalows specially designed for the use of cripples, with a community centre, near the Robert Jones and Agnes Hunt Orthopaedic Hospital and the Derwen Cripples' Training College. This will serve as a permanent tribute to a woman, herself a life-long cripple, who dedicated herself to the service of the disabled by creating and developing a country hospital with after-care clinics for the prevention and treatment of crippling, and a school for training in employment. The village

settlement was one of Dame Agnes Hunt's life-long wishes and it is hoped to build at least twenty bungalows at an average cost of about £2,000 each. The meeting was addressed by Sir Reginald Watson-Jones. Lord Kenyon, honorary treasurer, announced the receipt of a cheque for £10,000 from the Nuffield Fund for Cripples, and a cheque from an anonymous donor for £1,000. The chairmen of many county voluntary committees reported the striking success already achieved and the meeting revealed a most stimulating and encouraging spirit of devoted voluntary effort.

NEW YEAR'S HONOURS LIST

Knighthood conferred upon Mr Arthur Sims—Mr Arthur Sims of Christchurch, New Zealand, was honoured by His Majesty in the recent New Year's Honours List by the conferment of a knighthood. In 1946 Mr Sims made a gift to the Royal College of Surgeons of England for the endowment of a Commonwealth Travelling Professorship. A professor will be appointed each year and will generally be a prominent physician, surgeon or scientific worker resident in Great Britain or in Australia or New Zealand. The appointing authorities are also empowered, however, to elect as a professor a distinguished teacher from one of the other Dominions. The professor will be required to travel from the country where he or she is ordinarily resident to Great Britain, or to Australia and New Zealand, and to any other Dominion of the British Commonwealth, for the purpose of assisting in the advancement of medical science by lecturing, teaching or engaging in research.

It is the hope of the donor that the institution of the Professorship will not only lead to the establishment of closer links between scientific workers in the Dominions and in the older seats of learning and centres of research, but that the people of all nations will benefit. It is also hoped that it will be an important contribution to Imperial unity. Appointment of the professor is made by the Royal College of Surgeons of England on the nomination of the president, who is chairman of an Advisory Board consisting of the presidents of the Royal College of Physicians of London, the Royal College of Surgeons of England, the Royal Australasian College of Physicians and the Royal Australasian College of Surgeons.

Mr E. A. Nicoll who receives the C.B.E.

C.B.E. conferred on Mr E. A. Nicoll—We congratulate Mr E. A. Nicoll, a member of the Editorial Board of the Journal, on the honour of Commander of the Order of the British Empire, conferred upon him in recognition of the important work he has done for many years past in developing rehabilitation services for miners. Under the direction of the Miners' Welfare Commission, rehabilitation centres have been established in all the mining communities of Great Britain, and Mr Nicoll has been consulting surgeon to this service. In consequence of the excellent work carried out in the many rehabilitation centres where there are full facilities for gymnastic recreations and physiotherapeutic measures, a very high proportion of miners have been restored to full working capacity and have been able to resume work underground. A most excellent social service has been developed so that miners with residual disabilities have been enabled either to gain surface work or to be retrained in alternative occupations. The advisory committee responsible for the organisation of this rehabilitation service for miners, under the chairmanship of Sir Reginald Watson-Jones, includes Mr Alexander Miller of Glasgow (vice-chairman), Mr Gordon Irwin, Mr F. W. Holdsworth, Sir Thomas Fairbank, Sir Harry Platt, Dr Harold Balme and other leaders in the development of accident services and rehabilitation.

NEW APPOINTMENT

Appointment of Mr Jackson Burrows as consulting orthopaedic surgeon to the Royal Navy—The appointment of Mr H. Jackson Burrows as Civilian Consultant in Orthopaedic Surgery to the Royal Navy was briefly reported in the last issue of this Journal. Jackson Burrows was born in 1902. He read Natural Sciences at Cambridge and then went to St Bartholomew's Hospital, where both his father and grandfather had been students; after qualifying in 1927 he worked in the Professorial Surgical Unit there and became a Fellow of the Royal College of Surgeons of England in 1929. In the same year he returned to Cambridge where he spent six months at the Strangeways Research Laboratory investigating problems of tissue culture under Dr H. B. Fell. He was Beaverbrook Research Scholar in 1930–31, working under Alexis Carrel at the Rockefeller Institute and under Sir Arthur Keith in the laboratories of the Royal College of Surgeons.

From July 1931 Jackson Burrows served an apprenticeship of more than five years under Reginald Cheyne Elmslie in the orthopaedic department of St Bartholomew's, and in 1937 was appointed Assistant Orthopaedic Surgeon. He was also for one year Registrar at the Royal National Orthopaedic Hospital under A. S. Blundell Bankart and others. At the Royal College of Surgeons he was a Hunterian Professor in 1933, lecturing on "Tissue Culture in its Relationship to Surgical Pathology"; in the 1934 award of the Jacksonian Prize he was *proxime accessit* (to E. J. S. King of Melbourne, who in that year achieved his unique distinction of the hat trick). In 1938 Jackson Burrows was awarded the British Orthopaedic Association's Robert Jones Gold Medal for a study on *coxa plana*.

H. Jackson Burrows, who has been appointed Civil Consultant in Orthopaedic Surgery to the Royal Navy.

On the outbreak of the late war he became a full time surgeon in the Emergency Medical Service. He later served in the R.N.V.R., and was stationed at Portsmouth, at Aberdeen and at Sydney. He became a Fellow of the Royal Australasian College of Surgeons in 1945. After his naval service Mr Jackson Burrows returned to St Bartholomew's and also joined the surgical staff of the Royal National Orthopaedic Hospital. He was invited at the same time to become the first dean of the Institute of Orthopaedics, which was founded at this hospital under the aegis of the British Postgraduate Medical Federation of the University of London. The establishment of an entirely new teaching school has since been his first preoccupation; but he also came on the British Editorial Board of the *Journal of Bone and Joint Surgery* and from 1948 onwards has been assistant editor.

AN EXPERIMENT IN SOCIAL REHABILITATION

Mr David F. Thomas reports that the Scunthorpe Remedial Recreation Club, which was founded about eighteen months ago and continues to flourish, has for its object a redistribution of emphasis, from the physical to the mental, in the concept of rehabilitation. It is a voluntary organisation to promote the physical and mental well-being of those who are permanently handicapped by deformity.

The club is at present running two sessions to which patients are recommended by the orthopaedic surgeon, though it is not intended that the activities of the club should be confined to his patients; they are admitted on the production of a membership card on which is noted diagnosis, recommendations about remedial activity and any precautions which must be observed.

One night a week there is an hour's reservation at the town's swimming bath, and instructors from the local Swimming Club attend, on rota, with other voluntary helpers. No formal exercises are organised, and the patients are helped to feel that they are there primarily to enjoy themselves in company; nothing is done that would prompt self-consciousness. Every kind of swimming is taught to every patient, and those who eventually overcome their handicap to the extent of achieving some independence in the water and a reasonable standard of swimming ability are elected to full membership of the local Swimming Club; they then stop attending the special sessions of the Remedial Recreation Club. The Club has achieved its purpose when the hitherto shy and retiring "cripple" takes his place naturally among his normal fellows, unperturbed and undeterred by his physical differences. It is the Club's particular aim to restore its members —who through their physical handicap have become shy, or have lost confidence—to the social enjoyments of ordinary everyday life. Exactly the same principle underlies the activities of the Club in the other of its two weekly sessions. This takes up two hours, and is held in the gymnasium of one of the local schools. There are games for the children, story telling, handicrafts, and a finale of tea and cakes with a sing-song.

The Club does not, like many of the rehabilitation centres as they are at present constituted, act as a mere extension of physiotherapy departments and differing from them only in degree. Its purpose is to give to the members something that hospital organisations cannot give: adjustment to normal society despite physical abnormalities.

The ambulance service provides transport; and the education authorities have kindly lent the school gymnasium. The committee organising the Club is very widely based. It includes members of the hospital medical staff, general practitioners, the lady almoner at the local hospital, the secretary of the Swimming Club and members of the swimming baths committee, the assistant organiser of the Youth Club, the manager of the employment exchange, members of the physiotherapy department, the Medical Officer of Health and a nursing sister. Their function is to keep before them the essential ideal of the Club which the word "social rehabilitation" only summarises drably and inadequately, and to devise and exploit all material

means to achieve their end. Finance is necessarily important and the committee also concern themselves with finding money to extend the Club's activity.

It is hoped in time to have a single building from which all the interests of the Club can spring or be directed.

AUSTRALIA

ROYAL AUSTRALASIAN COLLEGE OF SURGEONS

The twenty-third annual general meeting of the College will be held in Adelaide from Saturday, May 20, to Wednesday, May 24, inclusive. The meeting will be attended by the third Sims Commonwealth Professor, Sir Reginald Watson-Jones, who will deliver the fourteenth George Adlington Syme Oration on "Rehabilitation and Resettlement in Surgery," and give a paper on "The Organisation of a Traumatic Service." Dr O. T. Clagett of the Mayo Clinic will give a paper on "Advances in Cardiovascular Surgery"; and Dr L. M. Eaton of the Mayo Clinic will discuss neurological and ophthalmological subjects. Professor Ida Mann will give a paper on "The Modern Approach to Congenital Abnormalities."

Gordon-Taylor Prize for the Primary Fellowship Examination—Five fellows of the Royal Australasian College of Surgeons who are also Hallett prizewinners of the Royal College of Surgeons of England, Messrs James Grayton Brown, Howard Hadfield Eddey, Robert Sutherland Lawson, John Stephen McMahon and Kenneth William Starr, have provided a fund by which a prize, similar to the Hallett Prize in England, shall be awarded on the results of the new primary fellowship examination in the Royal Australasian College. At their request, and with the permission of Sir Gordon Gordon-Taylor, K.B.E., C.B., the award will be known as the Gordon-Taylor Prize.

Invitation to Fellows of the Royal Australasian College of Surgeons from St Paul's Hospital, Vancouver, B.C.—Dr G. A. Lamont, chairman of the medical staff of St Paul's Hospital, Vancouver, B.C., has extended to fellows of the College an invitation to visit the hospital and take part in clinical proceedings and discussions. In extending this invitation Dr Lamont expresses hope that in this way Australian and Canadian surgery may be linked more closely.

AUSTRALIAN ORTHOPAEDIC ASSOCIATION

The annual meeting of the Australian Orthopaedic Association will be held in Adelaide from May 17 to May 21 inclusive. There will be a presidential reception, an official dinner, annual business meeting, two sessions for the presentation of papers and three sessions for clinical discussions.

NEW ZEALAND

ROYAL AUSTRALASIAN COLLEGE OF SURGEONS

The annual New Zealand meeting of the Royal Australasian College of Surgeons was held at Auckland from August 25 to 27, 1949. Orthopaedic papers were given.

Bone grafting—*Mr H. K. Christie* (Wanganui) read a paper on "The Grafting of Homologous Bone and Cartilage, with Some Notes on Recent Advances in the Grafting of Tissues in General." After reviewing the history and nomenclature of grafting, and particularly of bone grafting, he referred to modern advances such as successful homogenous grafting and especially the use of grafts preserved by refrigeration. Work on the fate of grafts testified to the special properties of cancellous chips in resisting infection, rapid adaptation and survival at a distance from other bone. They could be used in conjunction with sulphonamides, penicillin or streptomycin. Illustrative cases were described.

Repair of the flexor tendon—*Mr William A. J. Pike* (Auckland) paid a tribute to the modern advances made particularly by American surgeons in repair of the flexor tendons of the fingers. Some anatomical points were stressed: the shortness of the thecal sheath of the thumb, occupied by a single tendon; the importance of the annular thickenings of the other thecal sheaths; the smallness of the flexor tendons of the fifth finger and the continuity of their synovial sheath with the ulnar bursa. Mr Pike recalled that movement during the first three weeks of repair caused increased scarring; that thick tendons underwent central necrosis; that thin ones can hypertrophy to meet functional demands. Movement promoted the formation of a sheath. Tendon repair might be uneconomic; it demanded the intelligent co-operation of the patient. Suture should not be performed between the distal palmar and middle finger creases. Elsewhere primary suture might be performed under good conditions if the wound were recent and clean. If both tendons were divided, the profundus was alone repaired, the sublimis being excised except for its terminal three-quarters of an inch, which was preserved to prevent hyperextension of the proximal interphalangeal joint. Division of the profundus alone was not treated by suture unless near the insertion. Grafts, when necessary, were taken with their paratenon from palmeris longus or the long extensor of second or fourth toes. Stainless suture wire smaller than No. 36 and tantalum wire No. 35 proved too fragile. Post-operative exercises started in the fourth week and concentrated upon the distal interphalangeal joint. Median or ulnar nerve block with novocain had assisted exercise by relieving pain. An idea of the results obtainable was given by a review of twenty-nine cases. After sacrifice of sublimis the grip always lacked its final clenching power.

Hallux valgus—*Mr Waldron Fitzgerald* (Dunedin) considered that adolescent hallux valgus was commoner in New Zealand than in the United Kingdom, being dependent not only upon metatarsus primus varus, a congenital condition, but also upon unsuitable shoes and stockings. He advocated conservative treatment on the usual lines. The best operation was excision of the exostosis with the bunion and of the proximal half of the proximal phalanx; a Kirschner wire was then threaded through the phalanges into the metatarsal, being retained for ten to twelve days, after which it could be removed painlessly.

Dupuytren's contracture in the foot—*Mr J. Maxwell Clarke* (Auckland) described hypertrophy of the plantar aponeurosis analogous to that of the palmar aponeurosis. It had been mistaken histologically for fibrosarcoma. A case was shown in which excision had been performed.

Osteoid osteoma—*Mr J. Leslie Will* (Christchurch) reviewed the literature; described the etiology, pathology and treatment; and presented two personal cases.

GREECE

Report of Mr St J. D. Buxton's Visits—We have before us a report* on two visits paid to Greece during 1949 by Mr St J. D. Buxton. The first, in March, was under the auspices of the British Medical Association and the British Council; the second, in November, was at the invitation of the G.R.P.C.O. and the Public Health Division of the E.C.A. Mission to Greece. His task was particularly to study the orthopaedic aspect of the wounded and the problems of the crippled child.

Mr Buxton pays tribute to the great helpfulness and frankness of all he met, the good work being done—especially the forward surgery—and the fortitude of the Greek nation in the face of great problems. The magnitude of some of these problems is manifest from Mr Buxton's report and his recommendations. Considerable progress was observed between the two visits.

It seems that in the military hospitals, as in the homes for the disabled, segregation is little practised, and this reflects a lack of appreciation of modern methods in the management, for instance, of nerve injuries. Another lacuna is in the provision for rehabilitation in its widest sense. Fully trained physiotherapists are few, and little physiotherapy or other physical treatment on modern lines is possible. The provision of artificial limbs is deficient and the problems of resettlement and follow-up have not been seriously tackled. Orthopaedic surgery is recognised as a speciality, but recent injury is still in the hands of the general surgeons. The Hellenic Orthopaedic and Traumatological Association comprises travelled and experienced surgeons. Surgical tuberculosis is well dealt with at Voula, with leanings towards the methods of Rollier rather than the strict immobilisation favoured in this country. The provision is insufficient, so that the vicious circle of delayed and abridged treatment, familiar to us at home, has also to be contended with in Greece. There is shortage of equipment, as witness the want of such ordinary things as motor saws, electrocardiographs and plasma machines. The shortage of equipment and accommodation has limited the training of medical students and auxiliaries in the basic sciences.

In making recommendations, Mr Buxton has felt the need of reliable statistics of the number requiring orthopaedic treatment. Among his suggestions are: regular visits to military hospitals by consultants; segregation of cases; establishment of a physiotherapy and resettlement service, with a physiotherapy school; the reorganisation of the limb factories and the provision of a limb-fitting service; and the collection of data and formulation of a comprehensive national scheme by the Hellenic Society for Crippled Children. Mr Buxton's excellent report not only catalogues some of the problems and their remedies, but gives much practical detail of the means of putting these into effect.

Our colleagues in Greece and their friends are following a hard path, and, in offering them our very best wishes, we do so in no spirit of complacency.

BELGIUM

The Société Belge d'Orthopédie et de Chirurgie de l'Appareil Moteur holds ordinary meetings this year on February 18, March 18, April 22, May 20 and October 21. A special meeting on June 17 will be devoted to study of the reports of Dr Van de Voorde, Dr De Wulf and Dr Vereecken on " Le traitement des fractures anciennes du cou-de-pied." In October there will be an annual reunion with the Société française d'Orthopédie in Paris when there will be two main reports, " Les luxations de la rotule en dehors des luxations traumatiques récentes" by Dr Marcat of Paris and Dr Marion of Lyon, and " La Streptomycine en pathologie ostéo-articulaire " opened by Dr Gérard-Marchant of Paris and Dr Salmon of Marseilles.

* Buxton, St J. D. (1949): Report on Two Visits to Greece. London, 86 Brook Street: privately printed. Present State of Orthopaedic Surgery in Greece. Journal of Bone and Joint Surgery, 1949, **31–B**, 488.

Book Reviews

TUMORS OF BONE. By Charles F. GESCHICKTER, M.D., Professor of Pathology, Georgetown University Medical School, Consultant in Pathology, U.S. Naval Medical School, Consultant in Pathology, Mt. Alto Veterans' Administration Hospital, Pathologist-in-chief, Gallinger Municipal Hospital, Washington, D.C.; and Murray M. COPELAND, M.D., Professor of Oncology, Georgetown University Medical School, Consultant in Surgery, Gallinger Municipal Hospital, Washington, D.C., Special Consultant, Federal Security Agency, Public Health Service, Cancer Control Branch, Washington, D.C. Third edition. 10¼ × 7½ in. Pp. xviii+810, with 642 figures, 90 tables and 18 charts. Bibliography and Index. 1949. Philadelphia, London, Montreal: J. B. Lippincott Company. Price £5, 5/–.

The first edition of this book, published eighteen years ago, was based on the clinical records, radiographic appearances and pathological material from cases of bone tumour and closely allied diseases which had accumulated in the surgical pathology laboratory of the Johns Hopkins Hospital. Since that time many cases described in the first edition have been followed up and in this, the third edition, there are records of 500 new cases, making the total number of recorded cases over 3,000. This is the impressive background against which the book is written and, from this point of view alone, it must be regarded as an authoritative and indispensable work of reference.

Roughly one-third of the book is taken up by detailed accounts of the primary tumours arising in osseous tissue based on an analysis of approximately 1,400 cases, including 750 of osteogenic sarcoma, 294 of giant-cell tumour and 250 of osteochondroma. This is followed by descriptions of Ewing's tumour (167 cases), multiple myeloma (90 cases), secondary carcinoma and sarcoma (334 cases) and of tumours invading bone by direct extension. This edition includes a new chapter on tumours of the spine. The rest of the book deals with a large number of skeletal diseases which might be confused with or predispose to true neoplasia. This section, occupying about a fifth of the text and planned to provide guidance in clinical, radiological and pathological differential diagnosis, deals with hereditary chondro-dysplasia, bone cysts, generalised osteitis fibrosa, the many forms of chronic inflammatory bone disease, osseous changes in the reticuloses, and the skeletal dystrophies peculiar to young children. In this edition this section has been enlarged by the inclusion of accounts of monostotic and polyostotic fibrous dysplasia, osteoid osteoma and the skeletal changes in diseases of the endocrine organs. The general text is preceded by a short introduction written by two surgeons: Dean Lewis discusses the interpretation of clinical findings in cases of suspected bone tumour; J. C. Bloodgood deals with the steps to be taken in establishing an exact diagnosis and planning the course of treatment. These essays are commendably brief, attractively written and full of clinical wisdom. The rival claims of radiology and histology in the diagnosis of malignancy are impartially considered. In the first chapter there is an adequate description of the embryogenesis of bone and its relation to the formation of skeletal tumours. A short chapter at the end of the book deals with radiosensitivity of primary growths.

It will be obvious from this analysis of the contents of the book that it is far wider in scope than its rather misleading title would suggest. The general treatment of each subject is admirable. The clinical descriptions are graphically written; the very numerous radiological and morbid anatomical illustrations are of remarkably good and uniform quality. Some of the histological illustrations are very instructive and well selected, but on the whole they vary considerably in quality and rather too many of them are photographically poor and would prove of little assistance in the actual examination of a difficult biopsy. The histological descriptions are accurate but in dealing with the histogenesis of primary bone tumours the authors lay themselves open to criticism. They point out that the skeleton does not reach a final static form in early adult life and that under normal physiological conditions it contains cellular foci of undifferentiated skeletal mesenchyme which persist into adult life. It is boldly asserted that it is from such foci in certain specified situations that malignant osteogenic tumours arise, and with equal assurance that osteoclastomata arise in the vascular bone forming tissue which normally replaces calcified cartilage during development. Such attractive hypotheses should not be presented to the reader as well-attested facts. All highly malignant growths show anaplasia and their cells come more and more to resemble those which constituted the tissue of origin in embryonic life. Does every anaplastic tumour arise in residual embryonic tissue? The authors apparently believe that such is the origin of every osteogenic sarcoma. It can be argued with an equal degree of uncertainty that anaplasia is entirely due to a rapid growth, and it cannot be denied that the major lethal factor in osteogenic sarcoma is rapid cellular multiplication. With regard

to the osteoclastomata, if they arise in the young vascular bone which replaces calcified cartilage, why should they be so rare below the age of twenty ?

In the reviewer's opinion this tendency to dogmatise about the histogenesis of bone tumours is regrettable in a book which has so many excellent qualities and whose compilation has so clearly involved the authors in so much fruitful labour. For the surgeon who undertakes the heavy clinical responsibility of cases of bone tumour there is no better book of reference.—Geoffrey HADFIELD.

ILLUSTRATIONS OF SURGICAL TREATMENT, Instruments and Appliances. By Eric L. FARQUHARSON, M.D., F.R.C.S. (Edin.), F.R.C.S. (Eng.), Assistant Surgeon, Royal Infirmary, Edinburgh, Member of Clinical Teaching Staff, University of Edinburgh. Foreword by the late Sir John FRASER, Bt., K.C.V.O., M.C., M.D., Ch.M., F.R.C.S. (Edin.). Formerly Regius Professor of Clinical Surgery, University of Edinburgh. Third edition. 10×6 in. Pp. xii+391, with 319 figures and 16 plates. Index. 1949. Edinburgh: E. & S. Livingstone Ltd. Price 25/–.

This popular book, which is in nearly every house-surgeon's collection, contains an extract from the original preface stating the author's aim to illustrate those practical methods of surgical treatment which are rarely covered in text-books of general surgery. Apart from two sections on infusion and transfusion and an appendix on instruments and appliances, the teaching is entirely on fractures and orthopaedics. It is pertinent to ask whether Mr Farquharson's selection reflects faithfully modern British practice. The casual reader cannot fail to be enchanted with the sight and sound of every page, but the critical reader misses a description of those truly conservative and partially foolproof methods of treatment which do not lend themselves to photographic record. For example, a number of hyperextension manoeuvres to reduce compression fractures of the lumbo-dorsal and even dorsal spine are shown, but there is no mention of the renaissance of simplicity in the treatment of fractured spines, so ably sponsored by Nicoll from a mining area and by Guttmann from a paraplegic centre. In this chapter the teaching is of a choice pre-war vintage which nevertheless has become unpalatable to those who remember vividly the deplorable effects of hyperextension jackets applied during the stress of the bombing raids. Fractures of the os calcis are reduced by various means, such as hammering, the redresseur, screw-traction and the axial pin, but there is no appreciation of the results obtained by early active movement with freedom from weight-bearing. Possibly undue stress on the full reduction of bone deformity is seen in the treatment of sub-capital femoral fractures. Before pinning, the femur is manipulated into the fullest internal rotation and held there with the foot almost horizontal. The posterior gap opened up in the neck and the stretching of retinacular vessels must on occasion be considerable. Again, impacted fractures of the base of the first metacarpal bone are disimpacted, if need be by taps with a hammer.

Some minor criticisms are that continuous pulp traction by a suture is not in general use; that Denis Browne's " nut-crackers " for club feet do not appeal to most orthopaedic surgeons; that a walking sandal to control claw toes is impractical; and that anterior flat foot and metatarsalgia are by no means synonymous. The illustrations of surgical instruments include a number of museum pieces. The two pages devoted to eight tourniquets, for example, omit the two in everyday use, namely the Esmarch bandage and some variety of pneumatic tourniquet. Though the author's portable traction table, Braun's frame, Böhler's screw-traction apparatus, and Böhler's iron have each been seen in ten figures already, all four make a final appearance in the appendix.

Mr Farquharson's book is entirely admirable for the clear and concise text and for the excellent photographs and line drawings, but to a considerable extent it must be regarded as a lucid exposition of his own practice in fractures and orthopaedics. With some revision it would have an even wider appeal and could easily be the finest work of its kind.—K. I. NISSEN.

L'ORGANISATION DES OS. By P. LACROIX, Professeur à la Faculté de Médecine de Louvain. 9½×6¼ in. Pp. 230, with 87 figures. Index. 1949. Paris: Masson et Cie. Price 9.50 Francs (French).

How does a muscle cell differ from a bone cell or from a fibroblast ? What factors have been at work controlling the development, from indifferent mesenchymal tissue, of such contrasting and specialised types of cell ? For many years such problems of " cell differentiation " have fascinated those who study tissues under the microscope. The appearance of different cell types during early embryonic development provides striking examples of progression from unspecialised to specialised cells, and it is in the embryological field that the processes of cell-differentiation have been most closely studied.

Early embryologists regarded the fate of any part of the developing embryo as determined only by the inherent properties of the cells themselves, but experimental analysis has revealed that very often the differentiation of a particular tissue is brought about by outside influences acting on the cells concerned. An important task of experimental embryology has been to explore the nature of these controlling influences,

and in many cases it has been found that chemical factors are responsible. The discovery of the controlling influence of the anterior lip of the primitive streak was an outstanding example. Not only is the earliest differentiation of tissues in the embryo due to this type of chemical influence, but later in development there is an intricate co-ordination between nearby tissues, and this again appears to have a chemical basis. A well-known example concerns the eye region, where a necessary stimulus for the formation of the lens and conjunctiva is given by the eyecup as this outgrowth from the brain approaches the skin. The co-ordinated growth of many tissues depends on factors of this type, the local equivalents of the way in which a hormone can control the differentiation and development of a remote tissue. But this type of chemical influence, and the ability to respond to it by the production of specialised cells, are not restricted to early embryonic development. In pathological processes, for instance, adult cells often reveal a normally unsuspected plasticity and undergo a wide variety of transformations. Here too, chemical influences are often found to be the controlling ones. The present volume, by Professor Lacroix of the Institute of Anatomy of the University of Louvain, explores the extent of operation of such " organiser phenomena," as they are called, in bone tissue.

Readers of this journal will recall something of Lacroix's work from a brief article entitled " Organisers and the growth of bone," which appeared in 1947. On that occasion he summarised some of the experimental work that he had previously published on the subject in French and Belgian journals, and directed attention to its bearing on the role of " organiser " substances in bone growth and differentiation. This article is still the best introduction to Lacroix's work for the reader of English, but in " L'Organisation des Os " he presents in much more detail the experimental work on which his ideas are based. The book makes no attempt to be a formal or complete account of bone structure and behaviour, but is the description of an individual worker's material, amplified by illustrations from and references to the publications of others. Its matter is well presented, and it is clearly illustrated with numerous diagrams, drawings and photomicrographs.

Lacroix's work is based partly on ordinary histological studies on growing bones and partly on the results of transplanting various constituents of bone—periosteum, cortical bone, epiphysial cartilage and bone marrow—to other sites in the body, particularly to the subcapsular tissue of the kidney. His description of the behaviour of transplants from growing epiphysial cartilage is of outstanding interest. Active proliferation of cartilage cells takes place, the transplant continues to increase in bulk and undergoes the usual sequence of events that make up endochondral ossification. Columns of enlarged cartilage cells are invaded by cells of the surrounding connective tissue, and cartilage matrix is eroded by phagocytic giant-cells, just as occurs in the normal situation. Bone formation takes place on the cartilage scaffolding in the usual way, and even when the cells of the transplant have been completely killed by alcoholic fixation the same invasion by connective tissue cells and eroding " chondroclasts " occurs. These results suggest that these parts, at least, of the process of endochondral ossification are normally initiated by some chemical substance present in " pre-ossifying " cartilage. As well, the cartilage transplants quickly become surrounded by a " collar " of bone, formed by the host connective tissue. This is another " organiser " effect, and Lacroix believes that a similar stimulus is responsible for the development of the collar of bone that, in normal development, surrounds the margin of the epiphysial cartilage. Can any of these " organising " substances be extracted from bone, and identified more specifically ? Lacroix believes that this is possible, citing the work of Levander on the production of ectopic bone by means of alcoholic extracts of bone and cartilage, and he describes similar confirmatory experiments of his own.

Recent years have witnessed a great deal of advance in our knowledge of the chemical control of bone, both in its normal growth and maintenance, and under pathological conditions. The most significant studies have concerned generalised extrinsic influences, such as those provided by the hormones of the pituitary, parathyroids and gonads. Lacroix's contributions to knowledge are important because of the light they shed on quite a different type of chemical influence—local in origin and operation, and co-ordinating the development, maintenance and repair of the diverse tissues making up the skeleton. —H. A. Sissons.

FRACTURES AND DISLOCATIONS IN GENERAL PRACTICE. By John P. Hosford, M.S., F.R.C.S., Surgeon to St Bartholomew's Hospital. Second edition, revised by W. D. Coltart, M.B., F.R.C.S., Assistant Orthopaedic Surgeon to St Bartholomew's Hospital. 8×6 in. Pp. x+290, with 87 figures. Index and Appendix. 1949. London: H. K. Lewis & Co. Ltd. Price 21/–.

The author of this book, primarily intended for general practitioners, points out in the preface to the first edition its role as a shorter text-book for students. This double objective is difficult of attainment and has not been altogether achieved in so far as a manual for practitioners is concerned. The first seven chapters are devoted to the definitions and general principles of treatment of fractures and would be excellent reading for students. The major portion of the book gives a clear account of the commoner fractures and dislocations, together with sensible and orthodox methods of treatment. Indications are

given of those conditions where open reduction or fixation of fractures may be required, without providing technical details which would be required by an expert only. The general practitioner, however, needs more than this. For example, even though he may not reduce a single fracture, it may be important for him to know the symptoms of avascular necrosis of the head after fractures of the femoral neck. No mention is made of this complication. Again, non-union of the ulnar styloid is common after Colles' fractures and often leads to persistent tenderness. The doctor who knows that this disability is nearly always temporary can reassure his patient. Except for these omissions the book is excellent, clearly expressed and very well produced with good line drawings and radiographs. It can be most strongly recommended as a shorter text-book for students.—V. H. Ellis.

MAJOR ENDOCRINE DISORDERS. By S. Leonard Simpson, M.A., M.D., F.R.C.P., Physician, Willesden General Hospital, with charge of Diabetic and Endocrine clinics, Endocrinologist, Princess Louise Children's Unit of St Mary's Hospital, Consulting Physician and Endocrinologist, Soho and Samaritan Hospitals for Women, London. Second edition. 9×6 in. Pp. xxii+532, with 89 figures. Index. 1948. London: Oxford University Press. Price 42/–.

This, the second edition, has been brought up to date, much having been rewritten. It reflects very largely the considered opinions of the author, and so provides stimulating reading at the expense of balance in the attention given to various subjects. The reader will not, therefore, find it suitable as a reference for many endocrine conditions which are treated somewhat scantily, although there are many sections that he will find very profitable. This is by no means a reflection on the book, and in fact this is not intended to be a text-book or a complete book of reference. The discussion of conditions such as adipose gynandrism, the recognition of which is largely due to the work of the author himself, is well done; but here again the discussion reflects very largely his own ideas, which are of interest to the specialist but may prove somewhat difficult for the student. The illustrations are good but still leave room for improvement and addition. These criticisms are minor ones in a book of great merit, whcih can be strongly recommended to anyone who has an interest in the subject of clinical endocrinology.—E. F. Scowen.

ARMY FOOT SURVEY. An Investigation of Foot Ailments in Canadian Soldiers. By Colonel R. I. Harris, M.C., R.C.A.M.C., and Major T. Beath, R.C.A.M.C. 11×8 in. Volume I—Main Report. Pp. ii+143, with 36 figures. Volume II—Appendices, with 77 figures and many charts. 1947. Ottawa: National Research Council of Canada. Price $1.00.

This survey is based on the examination of the feet of 3,619 recruits for the Canadian Armed Forces, both on enlistment and during their period of training. The examinations were carried out with great thoroughness, the clinical findings being correlated with radiological and footprint examinations. A standard radiological method was worked out which can be recommended for general adoption. The footprints were obtained by a new and ingenious method, using a rubber mat marked with five ridges of differing heights, which gives a clear visualisation of the amount of pressure falling on any area. The facts were recorded on punched cards, so that a valuable mass of information is readily available for further study.

It is unfortunate but perhaps inevitable that in a study of this sort the presentation of the facts elicited can be influenced so much by the personal bias of the investigators. For example, they were very conscious of Morton's thesis on atavistic conditions of the first metatarsal segment, and by the presentation of their observations they convincingly disprove certain of his tenets concerning the effect on function of such structural variations. On the other hand, except for passing mention in the summary, they have ignored the functional effect of a relative elevation of the first metatarsal head either as a primary abnormality or in consequence of supination of the forefoot. They noted abnormal weight-bearing on the pad of the great toe, a frequently associated valgus deformity at the ankle and the associated hallux rigidus, but they did not correlate these observations, and attributed the hallux rigidus to the secondary contracture of the plantar fascia. Perhaps the functional significance of the syndrome could still be unravelled by further analysis of their records. They rightly lay great stress on the association between postural valgus at the subtalar joint and equinus at the ankle caused by short calf muscles. This they regard as a new observation, though its importance has long been recognised here. They consider the structural weakness of the subtalar joint to be the primary defect and dismiss the short calf muscles as a secondary phenomenon. This is the reverse of the usual view of cause and effect, so that further study is clearly needed on this problem.

The authors bring out once again, and rightly stress, the fact that shape is a poor criterion of function. They show that such conditions as so-called flat foot and hallux valgus are not in themselves a bar to good function, and that the functional efficiency of feet with these characteristics depends upon their cause and upon such associated conditions as stiffness of the joints concerned. It is a pity that as many as possible of those examined while in training could not have been assessed again later. It was recognised during the

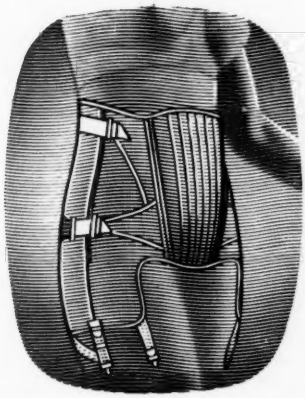
war that some foot disabilities might stand up to the initial training and yet break down later under more prolonged strain. For example, pes cavus with clawing of the toes was not found to cause any real disablement during initial training, yet such feet often degenerated fairly rapidly under active service conditions. Although, consequently, the period of observation in this survey is too short for final conclusions, it is, nevertheless, an important and valuable contribution meriting careful study by all orthopaedic surgeons. —T. T. STAMM.

THE NEUROANATOMIC BASIS OF SURGERY OF THE AUTONOMIC NERVOUS SYSTEM. By Albert KUNTZ, Ph.D., M.D., Professor of Anatomy, St Louis School of Medicine, St Louis, Missouri. 9×6 in. Pp. 83, with 11 figures. Bibliography. 1949. Oxford: Blackwell Scientific Publications. Price 16/6.

This little monograph consists of two portions, an earlier half which is a brief description of the autonomic nervous system and a second part concerned with certain aspects of the surgery of this system. As is to be expected of the author of a well-known major work on the autonomic nerves, the first portion is authoritative and constitutes a succinct survey of the autonomic system for those already initiated into its mysteries. The survey is, however, too concentrated and staccato in presentation to be readily understood by the novice. The very brevity, indeed, has led to some statements which if not incorrect are, without qualification, confusing. Thus (p. 20), the phrenic plexus is stated to supply the diaphragm and (p. 33) " peripheral rami " of the otic ganglion are described as innervating the tensor tympani and tensor veli palatini muscles. The description of the ganglion terminale is so brief as to be almost meaningless and the account of the " accessory " sympathetic ganglion related to the internal carotid artery and the cavernus sinus is not clear. Nevertheless, within a very short space Professor Kuntz has given a well balanced survey of a subject abounding in exceptions and special cases.

The second half of the monograph is devoted to anatomical and physiological considerations on the surgery of the autonomic nervous system. It contains, again within small compass, many facts of clinical significance and importance, and will be read with real interest by anyone concerned with the surgery of the sympathetic. In the more general introductory section of this portion of the book attention is given to the possibility and nature of " sensitisation " of effectors by sympathectomy and to the capacity of autonomic neurones for regeneration. Periarterial sympathectomy is mentioned briefly but is, justly, dismissed as a therapeutic measure lacking anatomical foundation. There follows a section on the surgery of the sympathetic trunks with special reference to those anatomical conditions which tend towards incompleteness in removal of the relevant autonomic fibres. The explanation of failure to achieve complete sympathetic denervation in certain parts of the body leads to a consideration of sympathetic pathways independent of the sympathetic trunks themselves. This aspect of Professor Kuntz's work was of considerable interest to the reviewer who, with Dr P. A. G. Monro, has also been concerned to determine the explanation of " escapes " following technically complete sympathectomies. Professor Kuntz's work in this regard has been chiefly in relation to sympathetic denervations of the upper extremity. Our material has been principally from the lumbar region. Apart from minor details, however, the results of both approaches are complementary and show how important the " intermediate " sympathetic ganglia are in explaining " escape " areas. These ganglia, hitherto ignored in the clinical literature, are found in the rami communicantes or in the spinal nerves themselves and were first adequately described by Professor Wrete of Upsala. Dr Kuntz records an intermediate ganglion adjacent to the ventral root of the second thoracic nerve which contained more than 20,000 cells, and from which a large bundle of fibres could be traced distally into this nerve trunk. An intermediate ganglion of this size is unusual, but such records show how impossible it may be to achieve, by classical paravertebral sympathectomies, total removal of the influence of the sympathetic nervous system on even a limited region of the body. The monograph is completed by brief surveys of splanchnicectomy, pre-sacral neurectomy and parasympathetic nerve resection, including vagotomy.

It is, perhaps, a measure of how much has been learned about the sympathetic nervous system in the past twenty years that there is no mention of Hunter and Royle in this monograph. On the other hand, however, the fact that Wrete's intermediate ganglia have remained unmentioned in surgical literature until 1949 is an index of what still remains to be learned—and applied—in this field.—J. D. BOYD.



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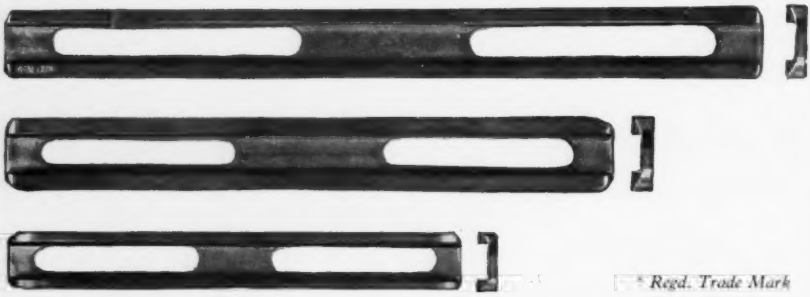

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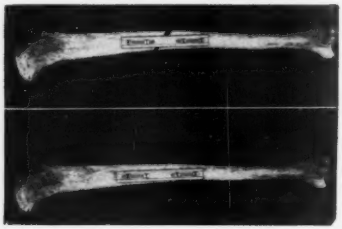

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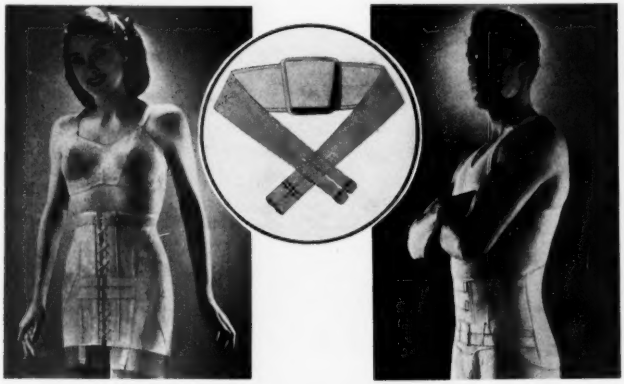

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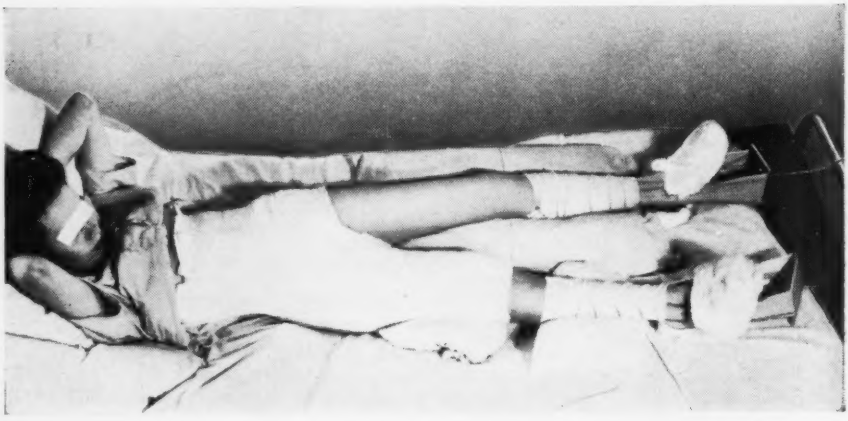

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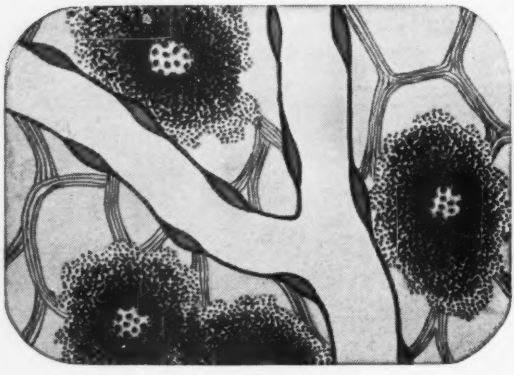

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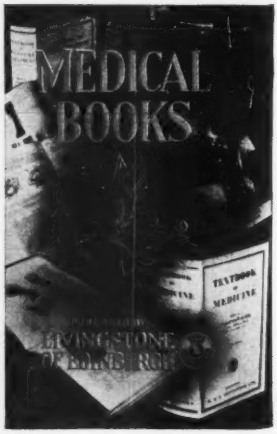

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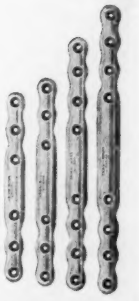

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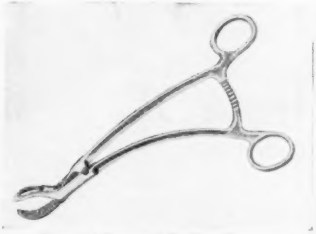

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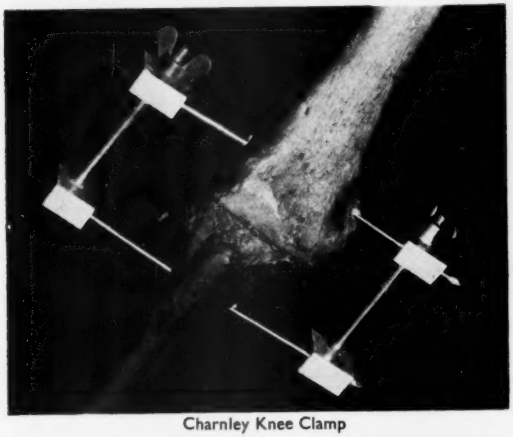

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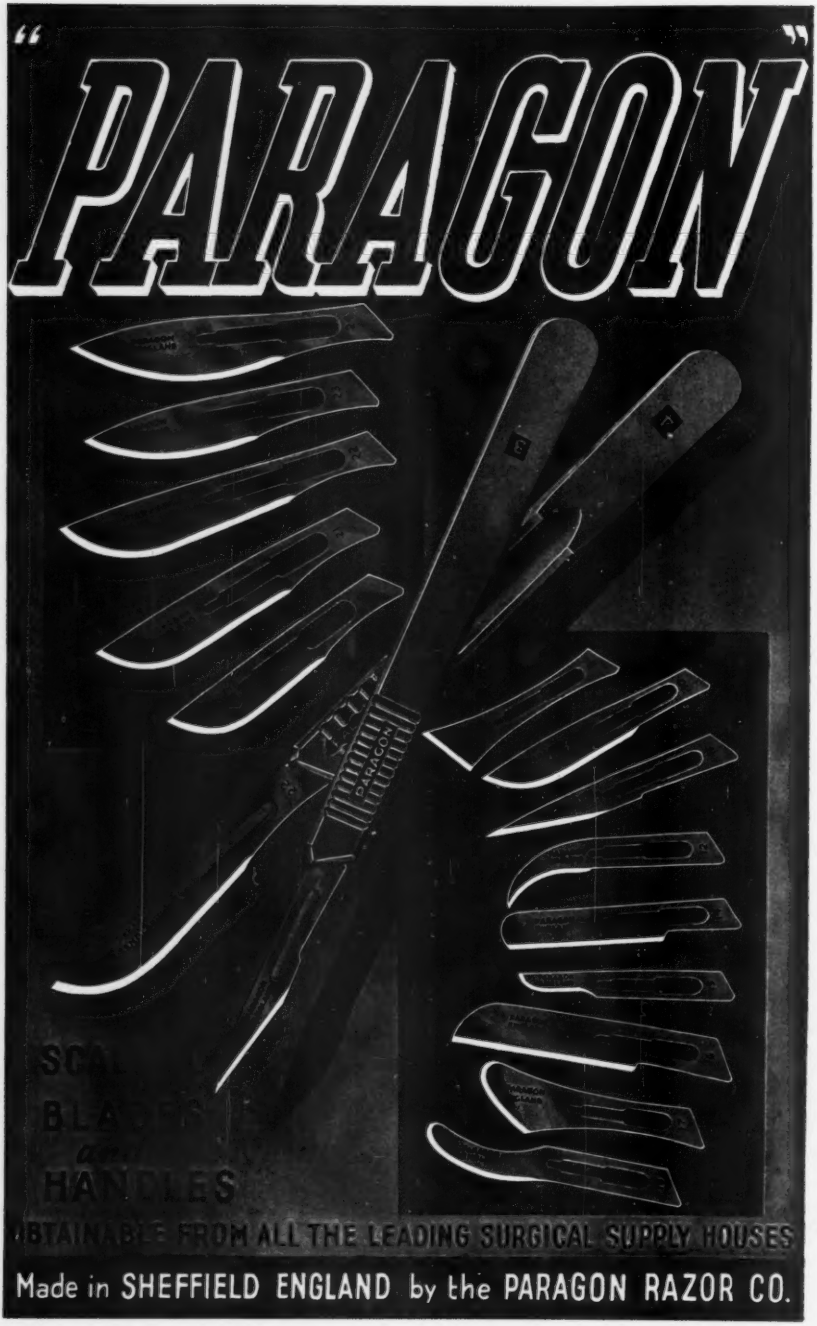
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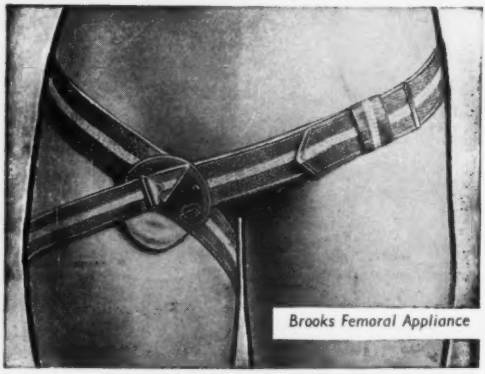

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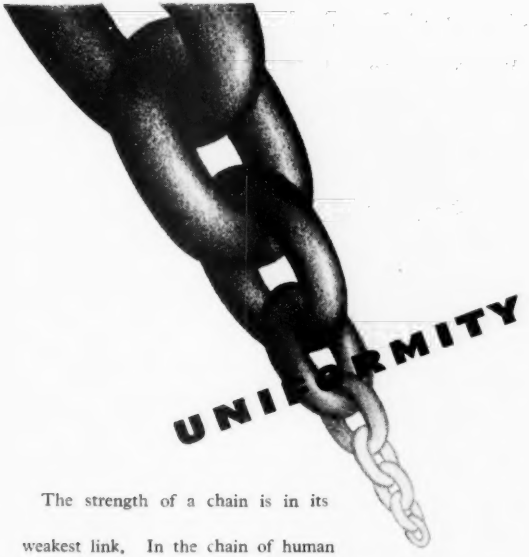

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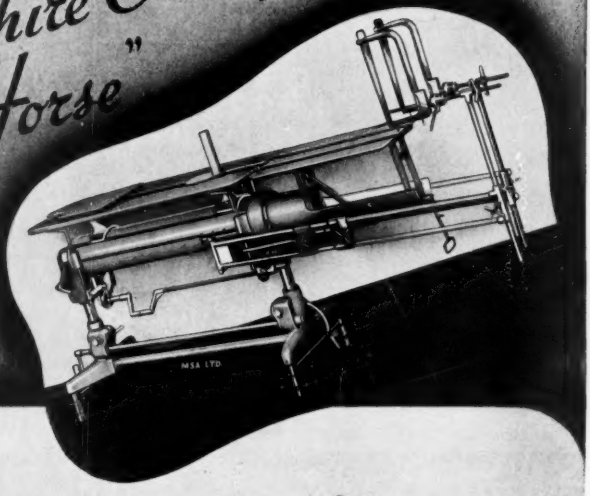

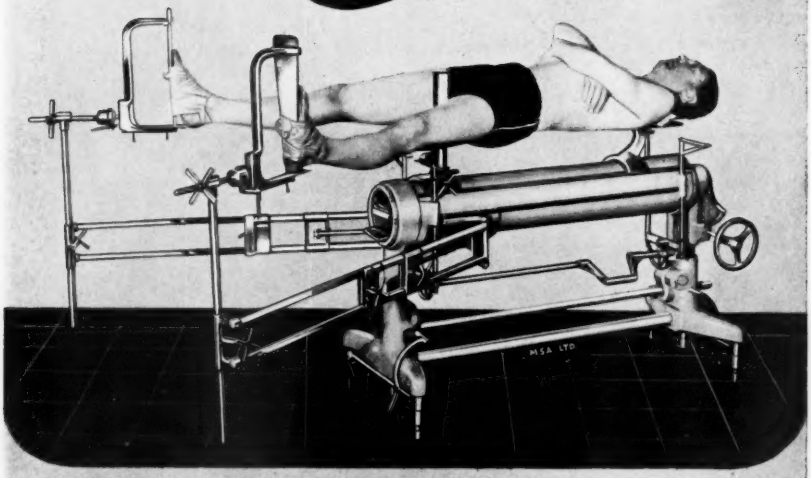

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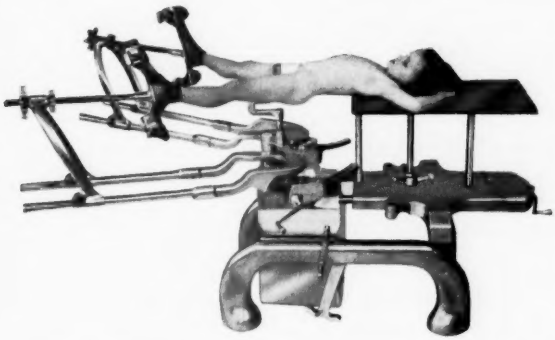

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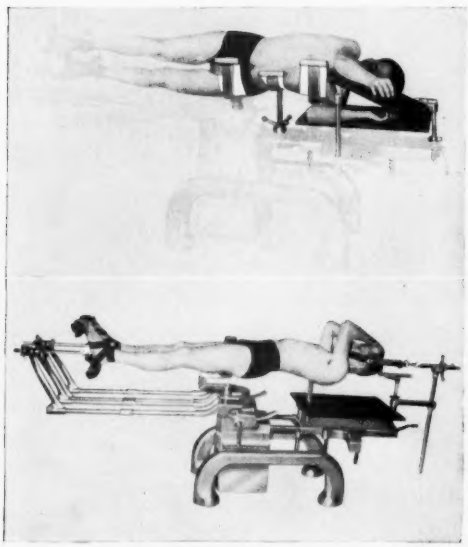

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